ESCUELA TÉCNICA SUPERIOR DE INGENIEROS INDUSTRIALES Y DE TELECOMUNICACIÓN

TRABAJO FIN DE GRADO

GRADO EN INGENIERÍA EN TECNOLOGÍAS INDUSTRIALES

Development of a generic requirements catalogue of Volkswagen Navarra's product for new launches.

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EXECUTIVE SUMMARY

The project is focused on the **development of a catalogue with generic technical requirements** that must be achieved by next generations of car models inside Volkswagen Group, especially vehicles of Volkswagen Navarra, where it has been carried out. This catalogue is an important document of the Project Premises, one step of the **PEP**, which is the **process** employed at Volkswagen Group **to design and launch a new model**.

In that step, the catalogue must be followed point by point to **study the feasibility** of each one of the requirements, which are mainly thought to avoid past **problems** related **with the assembly of the car emerged in the factory**, as well as ensuring the continuity of successful methods, introducing new assembly concepts, improving the ergonomics of the workers, etc.

To introduce the project, the current situation of the market position and sales of Volkswagen has been described, as well as the explanation step by step of the production process performed in Volkswagen Navarra to have a slight but clear idea of the company's working method and its reliability and accuracy. In addition, the **different sources consulted** to introduce the points of the catalogue have been explained **with clarifying examples**, as well as explaining and analyzing the informatics tool employed to save the catalogue points.

KEY WORDS: Requirements catalogue, Volkswagen Navarra, APQP, Product Emergence Process, GESPRO, product modification.

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1 INTRODUCTION

The present project has been carried out in the background of an **internship** in Volkswagen Navarra, being part of the team of "Pilothalle", a working group inside the department of **product's technical area**, one of the main departments of the factory. "Pilothalle", which means something like "pilot factory", influences the **development of new product** from early phases to ease its throwing in the quality parameters, costs and required periods. It manages the analysis and the problem solving in the productive process guaranteeing the perfect assembly of the car, its geometry and the acceptance grade from the optics of the final client. It also coordinates the sending of pieces to other factories such as spares. Finally it constitutes a platform of information exchange with other factories, as in the case of the Volkswagen Polo, Volkswagen Navarra is the **Leader Factory** that has to manage the homogeneity of the processes as possible so it involves a quality product in all of them.

The main purpose of the internship was to **develop a catalogue of generic technical requirements** for future models in Volkswagen Navarra that would be sent to the principal headquarters in Wolfsburg. In addition, it would serve for other Volkswagen factories abroad (e.g. Russia, South Africa, etc.) as it has been **written in English**. The project has been developed thanks to personal experience and commitments performed in the past four months at Volkswagen Navarra.

The purpose of this catalogue is to get a deep knowledge about the necessary product's generic requirements that one car of the VW Group must achieve and the process carried out to fulfil those requisites, as well as understanding the development performed to gather every single point of the catalogue. A description about the importance of the automotive industry in Navarre and Spain has been implemented in order to have a clear idea of its current situation and the local and global positioning of the factory and the group, as well as the global situation of Volkswagen Group, with some data concerning market share and worldwide competition.

As it is widely known, VW Navarra assembles the Polo model, starting with the very first prototypes and after with pre-series cars before starting the definitive production of Polo models that will be released to the market so every customer can access to them. However, before starting with any assembly, the company needs to know the

requirements involved in the design of every model. It is not the first time that a requirements catalogue is developed, however, the previous ones were carried out for specific models, very useful for that model but for the next one it required to perform a new catalogue. Now is the time to have a catalogue with generic requirements that will serve for every future model to be launched, sending it to Germany so it can be available for all the factories of the Volkswagen Group.

Whenever one problem appears, it must be deeply defined to find out the best way to avoid it in the future. As it is shown in the following diagram, after defining the problem some ideas are proposed in order to achieve a solution that will be used to make a first design of the modification of the product. The engineers and main specialists of the different areas will decide the best solution. The catalogue of the present project is mainly based on these solutions thought in the factory, but these are not the final solutions in most cases because there must be sent to the headquarters in Wolfsburg where the engineers will decide if every solution proposed is feasible and, if so, carry out each one to make the final design of the product modification. The following figure, extracted from "Diseño de Producto Industrial" (**Villanueva Roldán, P., Lostado Lorza, R., Sanz García, A., & Pernía Espinoza, A.V., 2011)**, shows the structure of the followed method.

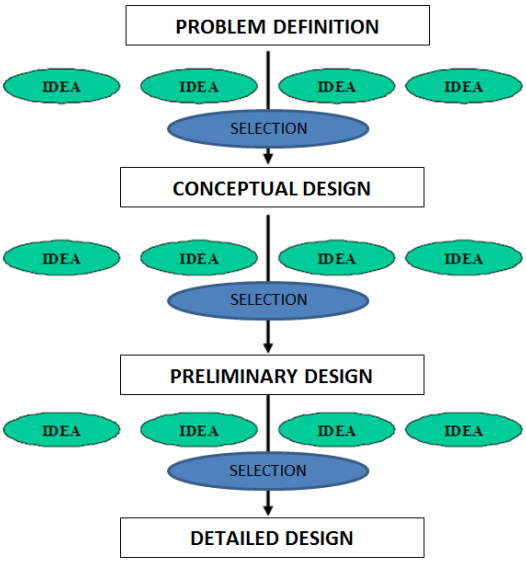


Figure 1: Product modification process.

Source: **Diseño de Producto Industrial.**

In order to have all the points of the catalogue saved somewhere an informatics tool has been used to have them structured through different categories and filters as it has been the tool performed to save problematic points on prototypes and series models. An evaluation of the current methodology to store those problems and their requirements to solve all troubles has been made. Thus, several **proposals** have been studied in order to **improve** the future **storage**.

All the data and information to develop the catalogue have been collected from **internal sources of the company**, interviews with specialists of different areas, managers, and so on. In addition, information from old catalogues and other documents has been studied and examined.

2 METHODOLOGY AND GOALS

To sum up, the methodology and steps followed to carry out the current project are the following:

1. Identify the investigation problem, that is, **find out the real purpose of the project** to achieve the solutions to solve such problem. In the present project this first step was focused on understanding what were the main problems to be solved, though in this case, a lot of small and varied product problems concerning the assembly of VW cars in the factory. This step involved the comprehension of the importance to develop the requirements catalogue and its value for the local factory.

2. **Bibliographic revision and experts consulting**. This step involved consulting old versions of requirements catalogues for concrete models, current documentation about the present model and its problems, paperwork about the daily prototypes troubles and many other documents concerning the assembly of cars in VW Navarra. Furthermore, many experts and engineers of the different areas of the assembly of models were asked for information about problems that occurred in the past and for solutions to solve all of them, as well as thinking

about new ways of avoiding troubles and current methods that were satisfactory and didn't involve problems to continue to working on the same way.

3. **Review, study and analysis of the product's historical evolution**. After consulting and understanding the previous catalogues written, it was the time of analysing them to find out which points would be feasible to be introduced in the new requirements catalogue. Some experts of the team of product's technical area helped to make a selection of some of those points.

4. **Define** the current **product framework** and the present methodology of storage. This step involves the explanation of the process to save all the product requirements as well as the daily problems produced at the factory concerning the assembly of cars. Furthermore, it is essential to clarify the working areas and groups encompassed by the present project and its catalogue developed.

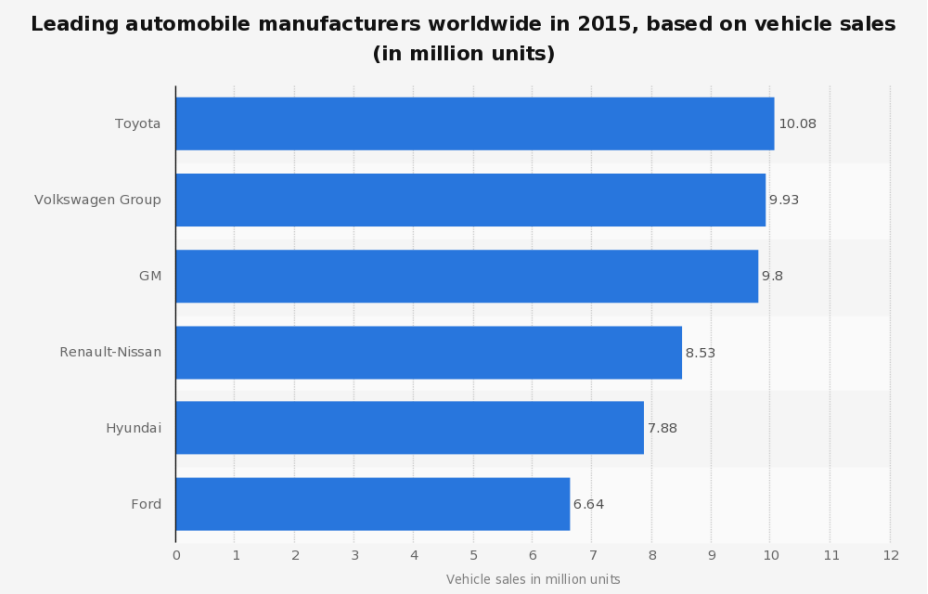
5. Exploration and **future considerations** concerning the existing methodology for its possible improvement. This part of the methodology carried out involves finding out ways to modify the current methodology to achieve a better and more accurate working process.

6. Development of the different steps performed to achieve the **product's appliance** and its **management**, focusing on the main working areas aimed to be delivered and the way to use the methodology for other factories and brands of the group.

3 VOLKSWAGEN GROUP

Concerning the automotive industry, it is important to emphasize its actual situation, as it currently is one of the most **globalized industries** all over the world. As it says the study "Globalisation and the car industry" (2014) from the web page Global Education, the car industry has been globalized from the very first days, with huge competition between many countries and brands to develop the best cars and to earn as much money as possible. Different size firms and groups compete in order to **gain market share**, but

few firms tend to dominate the market. Volkswagen Group, composed of 12 brands, it has been in the top three leading companies of the automotive sector during the last years as it is shown in the survey "KPMG's Global Automotive Executive Survey" from the professional service company **KPMG**. Furthermore, according to the statement "Leading automobile manufacturers worldwide in 2015" of the online statistics portal **Statista** (one of the world's most successful statistics databases), in 2015 Volkswagen was the second brand with more units of cars sold, only surpassed by Toyota, as it is showed in the following graph.



Graph 1: Leading automobile manufacturers worldwide in 2015.

Source: **© Statista 2016; Forbes; Various sources.**

Most recently, as it says the article "Volkswagen überholt Toyota beim weltweiten Absatz" (which means "Volkswagen overtakes Toyota in the worldwide sales") of the German newspaper Rheinische Post, in the first quarter of 2016 **VW Group has overtaken Toyota** as the company with **most cars sold worldwide**, showing the huge effort that the company is making to counter the big scandals about the diesel engines that recently emerged.

The competition in the automotive industry also occurs between brands of the same group, as it happens in Volkswagen Group. For example, Volkswagen and Seat compete

against each other because they have cars of similar performances and price in the same market segment.

The Volkswagen Group comprises 12 brands from seven European countries: Volkswagen Passenger Cars, Audi, SEAT, ŠKODA, Bentley, Bugatti, Lamborghini,

Porsche, Ducati, Volkswagen Commercial Vehicles, Scania and MAN. The following figure shows some data concerning VW Group.

Figure 2: Volkswagen Group brands.

Source: **Volkswagen Navarra; data from December 2014.**

Each brand has its own character and operates as an independent entity on the market. The product spectrum ranges from motorcycles (Ducati) to low-consumption small cars (VW, SEAT…) and luxury vehicles (Bentley, Porsche…). In the commercial vehicle sector, the products include ranges from pick-ups, buses and heavy trucks.

The Volkswagen Group happens to be also important in a wide range of businesses, including manufacturing enormous diesel engines for the Navy or power plants, turbochargers, turbo machinery (steam and gas turbines), compressors and chemical reactors. In addition, it also produces vehicle transmissions, such as special gear units for wind turbines, slide bearings and couplings as well as testing systems for the mobility sector.

Furthermore, the Volkswagen Group is present in some financial services, such as banking and insurance activities, dealer and customer financing, fleet management and leasing.

As it says in Volkswagen's Group Management Report of 2016, the Group operated, by May 26 of 2015, 119 production plants in 20 European countries and a further 11 countries in the Americas, Asia and Africa. Every weekday, 592,586 employees worldwide produce nearly 41,000 vehicles, and work in vehicle-related services or other fields of business. The Volkswagen Group sells its vehicles in 153 countries. The following figure embodies all the mentioned data.

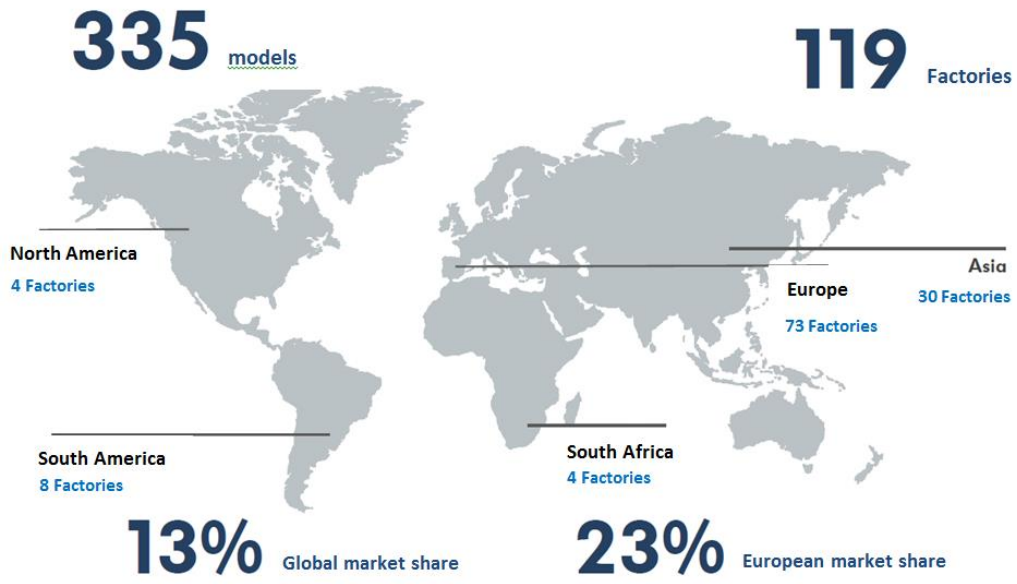


Figure 3: Volkswagen Group global distribution and market share.

Source: **Volkswagen Navarra; data from May 2015.**

The figure shows the huge importance of Volkswagen group and every of its brands all over the world, reaching every single continent with high performances and accuracy. The group sells many different models, providing each country reached with some varied vehicles of a wide range of prices, designs and features to try to reach the maximum number of clients.

3.1 Volkswagen Navarra

3.1.1 Polo sales

Turning to Volkswagen Navarra's case, it is the leading company producing the Volkswagen Polo. The factory is located in the industrial park of Landaben, in Pamplona, a northern city of Spain near France situated in Navarre. The assembly of Polo models in the factory of Volkswagen Navarra means approximately a **quarter of the entire gross domestic product** of the autonomous community of Navarre. However, the vast majority of the production, specifically the 91.3%, is exported largely to Europe and in smaller quantity to the rest of the world, representing the 32% of the total exports of Navarre, demonstrating how important this factory is for the economy of Navarre and Spain.

The Polo assembled in Volkswagen Navarra is exported to 52 different countries. Germany is the country with the biggest percentage of exported VW Polo, followed by France, Italy and Spain. The following figure shows the sales distribution of the Polo produced in VW Navarra.

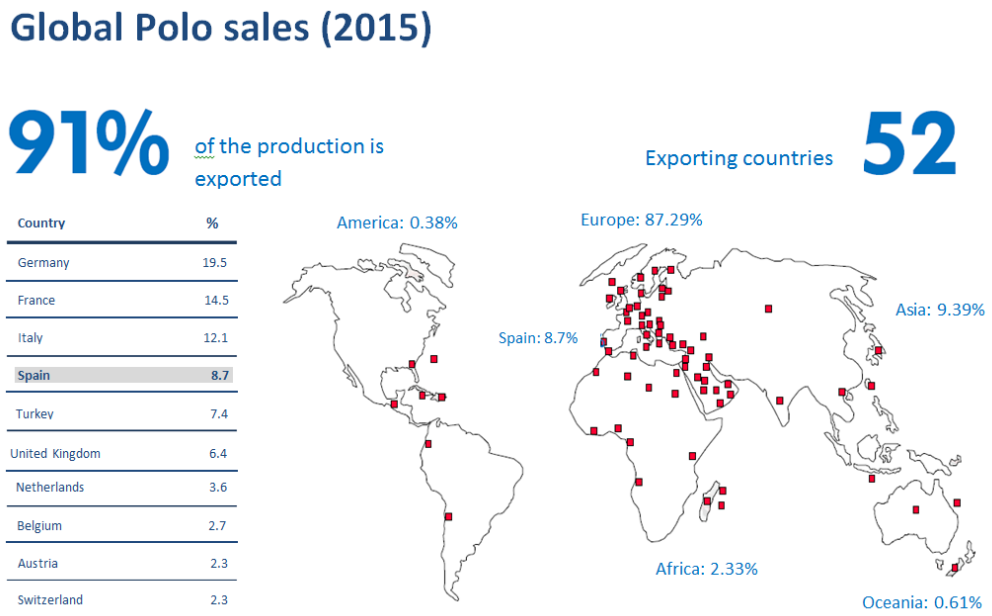


Figure 4: Sales distribution of VW Navarra's Polo.

Source: **Volkswagen Navarra; data from December 2015.**

Approximately 300,000 Polo models are produced every year to satisfy the global demand. To reach it, 7,607 people work in VW Navarra, with almost 4,500 of them that work every day at the assembly line to nearly produce one Polo every 54 seconds. However, to achieve this amazing production time an incredible coordination of all departments and employees must be carried out. From the first pieces assembled to the final revision of each Polo 13 hours are necessary to perform its entire production. Furthermore, nearly 4,500 pieces are part of each Polo. To assemble all of them an intensive and **detailed working plan** must be followed by all employees. In addition, the role of the suppliers is crucial, as 571 suppliers are needed to supply all the components of the Polo. Every single day 80-100 trucks are filled with completed cars to transport them to the customers, as well as 2-3 trains per day transport vehicles.

As it recently appeared in the news section of Volkswagen Navarra's web page, the **Volkswagen Polo produced in Volkswagen Navarra's factory** was in 2015 the **most produced and exported model of Spain**. Moreover, according to data of the global supplier of automotive business intelligence JATO Dynamics, the Polo occupied the third sales position of the European market with 229,000 registrations and a growth of 8% compared with 2014, and repeated another year in the top ten of registrations in the Spanish market with 25,127 registrations and an increase of 5.6% of the overall national registrations.

The Polo is a relatively cheap car which target client is from a medium economic level. Volkswagen tries to have the best balance quality-price concerning the Polo, basing his effort in the **"Anmutung" philosophy**, which is based in a **deep care of every** little **detail** of the car to perform a highly accurate and elaborated product. Concerning the customer's safety it is carried out a detailed examination of each car manufactured by Volkswagen. The mentioned examination is composed of several actions that are implemented during the production process with the aim of reaching an exact verification of the vehicle components to guarantee the highest quality cars.

Every few years the model is renewed through a long process of 48 months and 14 phases to develop the new car and start its production called PEP that will be further on deeply explained, describing every single step of the PEP.

3.1.2 Production process

To understand how the factory does to reach such a huge amount of production, it is necessary to explain how the production process is organized. The following figure represents the different steps of the production process.

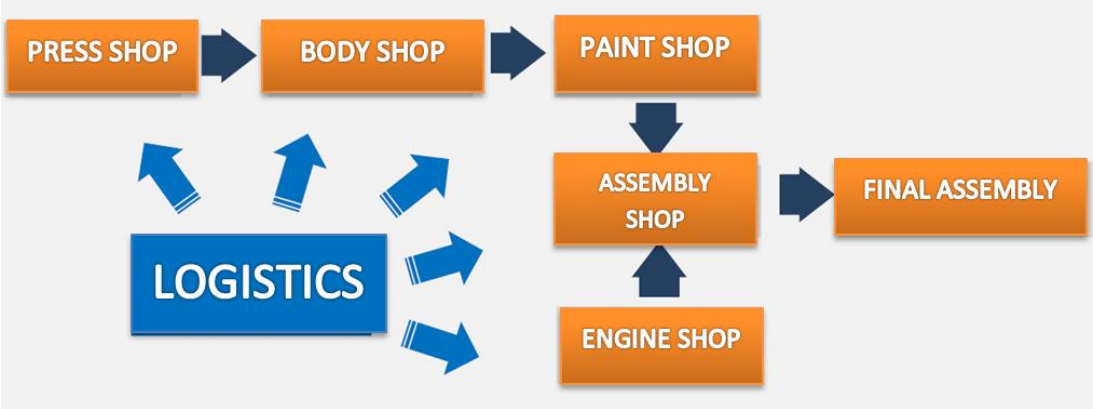


Figure 5: Production process. Source: **Volkswagen Navarra.**

-Press shop:

1. An external **supplier provides the raw material** which is the development of sheets that come to the factory already cut and placed in specific pallets, containing between 400 and 500 units each one. The N1A industrial plant is provided at present with three presses.

Figure 6: Presses introduction. Source: **Volkswagen Navarra.**

2. The **stamping process begins with the laying of the dies** in the presses. The die is the most important tool of the workshop, as it is in charge of the forming process,

cutting, punching and shaping the sheets developments up to configure the definitive piece. Therefore, the maintenance and servicing of this tool is really important. To that end it is necessary, among others, the laundry of matrixes, the milling machine, the lathe or the furnace for thermal treatments. Depending on the piece wanted the die placed will change.

Figure 7: Dies laying. Source: **Volkswagen Navarra.**

3. As soon as the dies are placed in the presses is the moment of **feeding the sheet**. This is an **automatic process**, by means of a few magnets that collect the sheets. Before its printing in the press, the raw material must be completely clean.
4. Each of three presses of this workshop is provided with a transfer system entrusted to collect the sheet, to move it between the different workstations and to **deposit the piece already finished** in the exit tape.

Figure 8: Transfer system. Source: **Volkswagen Navarra.**

5. As soon as the pieces are finished they are loaded in the specific containers across an exit tape. **A worker checks the product** at the end of the line, according to a few established control rules. The remaining cuttings in the process of the developments of sheets fall down to a few hoppers and are transported to a container to recycle it.

Figure 9: Way to Body shop. Source: **Volkswagen Navarra.**

-Body shop:

1. At the Body shop it takes place the **union of the different pieces from Presses and from other external providers** to form the body of the Polo. The activity of this workshop is characterized by its high automation degree, as more than 600 robots realize approximately 95% of the work.

Figure 10: Body shop introduction. Source: **Volkswagen Navarra.**

2. The underbody joint of the Polo is a "self-supporting structure". **The chassis**, therefore, **is integrated in the car body**. The process starts by forming the underbody 1, which consists of previous and rear floor, tunnel and crossbars. Later

on, it is added to it the tail, wheel arch and dashboard that form the underbody 2. In the crossbar a plate is placed with a **bar code that identifies this bodywork**, specifies its characteristics and determines its position in the production process.

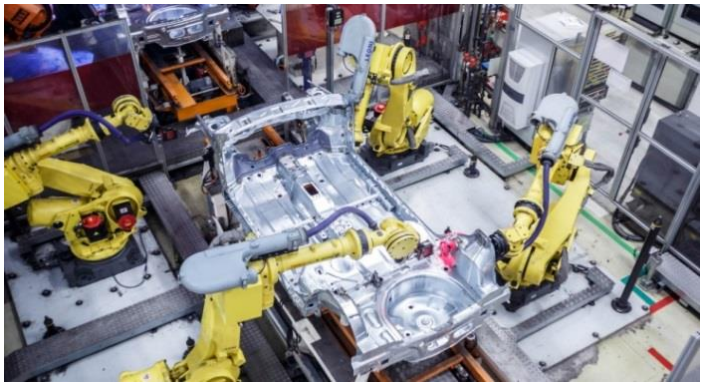


Figure 11: Underbody. Source: **Volkswagen Navarra.**

3. To the "autoframe 2" are placed the sides, which have been produced previously in other facilities, and the **manufacture of** the called **full body joint** begins.

Figure 12: Full body. Source: **Volkswagen Navarra.**

4. To the underbody 2 the shoring of the roof is placed to go to a geometry station with seven robots. Later on, the roof is placed and the union by means of **laser welding** with material contribution is carried out. This set is named full body.
5. The last process to complete the bodywork is the laying of the different **hang-on parts** (doors, hood or tailgate). Also, the wings are added. This process is realized by means of geometry manipulators.

Figure 13: Hang-on parts line. Source: **Volkswagen Navarra.**

-Paint shop:

1. The process begins with a pretreatment (TTS) of the bodywork consisting of a **high pressure wash and several chemical treatments**, with the target to eliminate of the sheet all kinds of grease, filings and free projections caused in the workshops of Press shop and Body shop. The treatments transform the surface of the body — until now irregular, electricity driver and capable of corrosion — into a **uniform, not conductive surface and very resistant to the corrosion**.

Figure 14: Pretreatment (TTS). Source: **Volkswagen Navarra.**

2. In the bath of cataphoresis (KTL) a **process of electrophoresis** takes place in which the painting bath is submitted to electrical tension: the body acts as cathode, attracts particles of painting dissociated so settles a layer of painting that acts like main recovering opposite to the corrosion.

Figure 15: Cataphoresis (KTL). Source: **Volkswagen Navarra.**

3. After finishing the KTL process the body changes its transport system and skips to a "skid" or skate. Once in the sealer line, the body is deposited in a turner trolley. Next, several **robots apply the sealing filler**, which guarantee the water tightness of the car. Finally, another two robots apply the PVC in the heelpieces.

Figure 16: Sealer line. Source: **Volkswagen Navarra.**

4. After finishing the water tightness process, the **painting of the body begins**. First the **base coat is applied** to the interiors with eight robots, previous doors, hood and tailgate opening with manipulators; another four robots apply a color base of electrostatic form with a catalyst in the exteriors; and in the metalized colors, three robots with two guns each one take charge of the aerographic application.

Figure 17: Base coat application. Source: **Volkswagen Navarra.**

5. After the review of the body for the retouchers and the drying of the water in the intermediate furnace, the **measurement of the thickness of the base coat with the paint checker** is realized. Finally, the clear coat 2K (2 components) is applied of similar form to the base, and the body is sent to the drying furnace.

Figure 18: Clear coat application. Source: **Volkswagen Navarra.**

6. The process finishes in the control line, where the **surface of the bodywork is checked visually**. The painted bodies are now sequenced in an intermediate warehouse and sent to the Assembly shop. Previously, the DVD will be placed in the roof, a stabilizing and anti-vibratory piece, and the waxes application will be realized in the underfloor of the body.

-Engine shop:

1. In the sequencer warehouse two processes are carried out in a simultaneous way: the **assembly of the doors and the power train**. The sequencer warehouse is the heart of the workshop as it stores and distributes the elements that have to be assembled.

Figure 19: Sequencer warehouse. Source: **Volkswagen Navarra.**

2. The power train line is divided into three sub-processes: the assembly line of the mechanical set ("Triebwerk"), the assembly line of the joint sub-chassis and the final assembly line of the power train ("Triebsatz"). In the picture it is possible to appreciate the **transfer from the "Triebwerk" set to the final "Triebsatz" line**.

Figure 20: Power train. Source: **Volkswagen Navarra.**

3. In the "Triebwerk" line the **union of the gearbox to the engine** is carried out afterwards to the preassembly of the gearboxes with interlock of the bearings and

the oil filling. Also, the complementary pieces are assembled to the engine (starter engine, refrigeration pipes, etc.).

4. The **supply of the sequenced gearboxes** to the "Triebwerk" line is realized with edge-guided trolleys, without driver.

Figure 21: Edge-guided trolleys. Source: **Volkswagen Navarra.**

5. In parallel with the mechanical set assembly, the **sub-chassis joint is assembled**. It is composed of the sub-chassis, the oscillating arms, the direction set, the stabilizing bar, the suspension tights and the pendulum support.

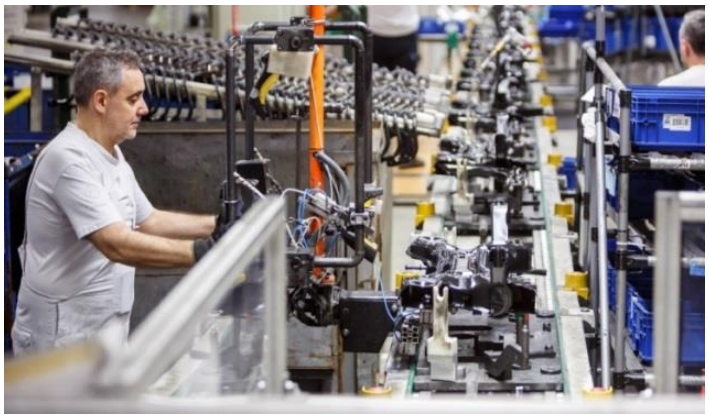


Figure 22: Sub-chassis joint. Source: **Volkswagen Navarra.**

6. The **transfer of the sub-chassis joint** from the "Triebwerk" line to the final "Triebsatz" line is realized by means of a robot.

Figure 23: Transfer robot of the sub-chassis joint. Source: **Volkswagen Navarra.**

7. As soon as the sub-chassis joint and the mechanical set ("Triebwerk") are finished they are **joined in the final "Triebsatz" line**. Along this line the bearings of the rest of gearboxes, the gearshift, the previous tailpipe, the alternator, the compressor of air conditioning, the refrigeration pipes and the set of the front suspension, between others, are added. Once finished it is **transported to** the workshop of **Assembly shop**, where it will join the car body.
8. Now is the **turn of the doors**. It begins when they come to this workshop from the Assembly shop. The doors come placed in couples over a rocker. The assembly of the anti-dust gasket, the opening handle, the crystal, the speakers, the lock, the exterior mirror and so on is made up to complete it.

Figure 24: Doors line. Source: **Volkswagen Navarra.**

9. The process ends with the achievement of the **SIDIS test**, where the operators **verify** that all the **electrical elements** of the door **work correctly**. As soon as this checking is finished, the doors are sent again to the Assembly shop.

Figure 25: SIDIS test. Source: **Volkswagen Navarra.**

-Assembly shop:

1. The assembly process begins with **the recording of the frame number**. In this section the doors are dismantled and sent to the Engine shop. The first elements joining the vehicle are the gaskets of the doors and tailgate, the rear belts and the airbag control module.

Figure 26: Section 1. Source: **Volkswagen Navarra.**

2. The cockpit or **dashboard is sequentially provided to the line**. Later on the roof lining and other elements like sunshades, amounts, complimentary lights, etc. are assembled. In last place the windshields are placed. With the operations in the

underbody (installation of brake and fuel pipes), the body is prepared for the incorporation of the power train in the "Fahrwerk" or marriage.

3. In the "Fahrwerk", the **body and** the **power train** from the Engine shop **are joined.** The union takes place thanks to a hydraulic elevator that rises the mechanical set to fit it into the body.

Figure 27: Marriage. Source: **Volkswagen Navarra.**

4. In this section the front of the vehicle is joined. Next, the **keys are recorded with a random number** assigned by a centralized system, which is communicated to the main switchboard of the vehicle.

5. Later on, the wheels are assembled in an automatic installation inaugurated in 2015, in which several **robots place simultaneously four wheels of the vehicle**. It is a highly efficient installation. Next, the filling of the brakes circuits, refrigeration and windshield washer is made.

Figures 28 and 29: Section 4. Source: **Volkswagen Navarra.**

6. The process continues with the assembly of the seats, the steering wheel and the doors, which came out at the entry of the workshop to be completed in the Engine shop. The already assembled car comes to the **checkpoint ZP6**, where the **final electrical functioning is checked**, the adjustments of the mobile elements are done and the checking of the final trims takes place. With it, the vehicle is prepared for its step along the last workshop: Final Assembly.

Figure 30: Checkpoint ZP6. Source: **Volkswagen Navarra.**

-Final Assembly:

1. In this first phase of Final Assembly the **alignment of the wheels and the headlights** is realized. Also the "EOBD" process (on-board process of electronic checking) takes place.

Figure 31: Wheels alignment. Source: **Volkswagen Navarra.**

2. In the booth the **running-in test** is realized **with rollers**: the braking and gears change systems are verified and a running-in of the engine is realized. Later a predefined routine is thrown in the engine switchboard, with the target to verify that all the sensors and actuators of the engine measure and behave as it is expected in a correct functioning.
3. In the third phase the water tightness of the car body is verified in an installation that simulates **external conditions of rain** that the car could possibly suffer.

Figure 32: Water test. Source: **Volkswagen Navarra.**

4. The vehicles realize a route at the **test track** in which, passing through different types of surfaces and slopes, the correct functioning of the cars is verified.

Figure 33: Road test. Source: **Volkswagen Navarra.**

5. Previously to the final delivery checking processes are realized in ZP7 and ZP8 lines. The first examination is carried out in the three lines of ZP7 (before test

track). The final examination **ZP8 involves the end of the productive process**. The car gets out of the line "sold", with the destination of its client.

Figure 34: ZP7 and ZP8 lines. Source: **Volkswagen Navarra.**

3.1.3 General layout

VW Navarra has a vast surface for its factory divided into **several industrial plants**. Each of them allocates one **specific work concerning the production process**. To have an idea of the distribution of the different industrial plants around the factory, the following figure shows the general layout of the factory to develop all the production process.

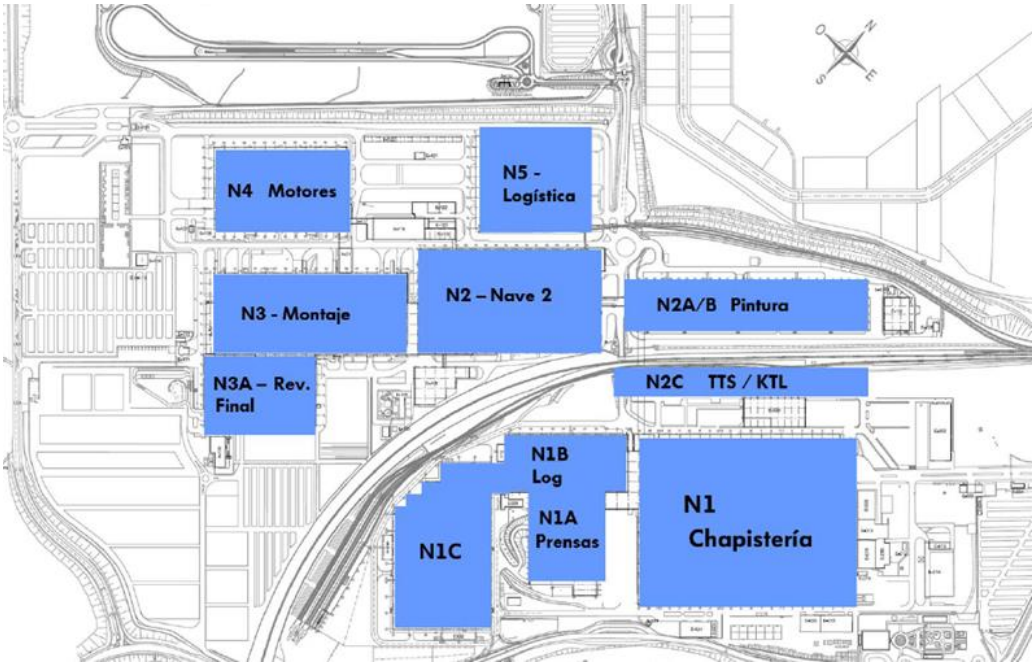


Figure 35: General layout. Source: **Volkswagen Navarra.**

As it has been mentioned recently the present project has been performed being a member of the department of product's technical area, which is located in the "Chapistería" industrial plant, N1, which is the Body shop plant. Inside N1 plant it is also located the **Try Out centre**, where the **prototypes of new models are assembled** to find out problems to try to avoid them later on and to start to learn how the assembly line should be afterwards to prepare the factory operators for the SOP, that is, the start of production where the final car starts to be massively produced to be delivered to the final customer. Such centre has been typically visited to know the status of the prototypes and to see the different problems daily emerged to gather as many information as possible. Furthermore, the **measurements room** (right next to the Try Out centre) has also been visited to attend to weekly meetings over the daily-emerged problems, studying deeply one by one. These mentioned meetings are deeply explained on the main point of the project.

Concerning the different industrial plants of the factory, most of them have been visited to see all the production process and understand in a better way the daily work of the operator of every production process' step. In addition, some **meetings** were **carried out** at plants such as N3 – "Montaje" (Assembly shop), N4 – "Motores" (Engine shop), N2A/B – "Pintura" (Paint shop) or N1A – "Prensas" (Press shop). Those meetings were crucial to collect many requirements or points for the catalogue, all of them taken from people that have been specialized on their areas for a long period of time and have big experience with the product assembled and produced in the factory and their opinions had to be taken into account for the development of the project. Their clear and specific explications helped a lot to achieve it.

4 APQP

As it was defined in 2015 in the document "Advanced Product Quality Planning (APQP)" from the web page of **Quality-One International**, the APQP is a structured **process** of defining and establishing the steps, procedures and techniques necessary **to develop products in industry**, particularly the automotive industry, guaranteeing that the product satisfies the client.

APQP is a method that appeared at the end of the 1980s by a commission of experts gathered from Ford, General Motors and Chrysler, the **'Big Three' US automobile manufacturers**. This commission invested five years to analyze the then-current automotive development and production status in the US, Europe and especially in Japan. At the time, the success of the Japanese automotive companies was starting to be remarkable in the US market. APQP is employed today by these three companies and some affiliates.

APQP serves as a guide in the development process and it is also a standard way to share results between suppliers and automotive companies. APQP is composed of five phases, having each of them some topics that will have to be monitored. These topics will be all completed before the production is started. They cover such aspects as: design robustness, design testing and specification compliance, production process design, quality inspection standards, process capability, production capacity, product packaging, product testing and operator training plan, among other items. The APQP phases, mainly taken out from the document "APQP or Advanced Product Quality Planning" of the web page **Omnex** and the document **"**PLANIFICACIÓN AVANZADA CALIDAD DE PRODUCTO" from the standard **ISO TS16946**, are described down below.

4.1 Phase 1: planning and definition of the project

First phase is thought to **guarantee that the customer needs and wishes will be mostly fulfilled** by the final output produced. It is necessary to review the contract with the service suppliers. Some of the objectives of this stage are the following:

- Design and feasibility goals.
- Preliminary bill of material and process flow chart.
- Preliminary document of special product and process features.
- Product assurance planning.
- Management support.

4.2 Phase 2: design and development of the product

This area encompasses a thorough **review of the product design** (engineering) requirements and concludes with an approval of the design reliability. Some of the most important documents carried out are:

- Design failure method and analysis of its effects.
- Design for assembly and production.
- Design checking and review.
- Prototype assembly process.
- Engineering drawing and requirements.
- New equipment available and testing.
- Team feasibility commitment and management support.

4.3 Phase 3: design and development of the process

This third stage is focused on **introducing** with care the different c**ustomer wishes and requisites into the production process**. Phase 3 involves the following outputs:

- Packaging standards and specifications.
- Review of the product and process quality system.
- General layout and process flow chart.
- Development of characteristics matrix.
- Pre-launch control plan and analysis of process failure and mode effects.
- Process steps explanations.
- Management support.

4.4 Phase 4: product and process validation

The penultimate phase of the APQP method consists on evaluating all the packaging and measurement systems to **confirm the production process and the product requirements**. The following outputs must be achieved:

- Production trial run.
- Preliminary process capability study.
- Production Part Approval.
- Product validation testing.
- Production control plan.
- Quality planning authorization.

4.5 Phase 5: feedback and corrective action

The last step of the APQP process involves **rethinking the processes and steps achieved** in order to improve them and solve some problems. Outputs:

- Reduced variation.
- Customer satisfaction.
- Documentation and service.

Concerning the case of Volkswagen, they call its process of product development as PEP. It is a method very similar to the APQP and has many points in common to the American process. However, there are many differences in their steps or in some cases one phase of the PEP is a mixing of phases of the APQP method. The following point explains with detail the PEP method applied in Volkswagen Group step by step and the relation between both processes.

5 PRODUCT EMERGENCE PROCESS (PEP)

The PEP ("Produktentstehungsprozess" in German) or **Product Emergence Process** is a standardized process that regulates the **steps to follow in the development of a new vehicle**, from its very first sketch or design to its introduction to the market. The PEP starts **48 months before the production** of the new car starts. It is a long process of fourteen phases, each of which contains different hits or steps that have to take into account finances, market, documents, catalogues, process, styling, product and suppliers, among other issues.

The objective is to standardize the development process of the product in order to provide several advantages:

- Speed up and accelerate the development process of a new product.
- Reach a better product tracking.
- Establish and distribute with clarity the responsibilities concerning the taking of decisions.
- Coordinate the inversions with the maturity state of the project, liberating the resources at the time and place they are necessary.
- Fulfil the terms for its clients (internal and external).

Improving the quality of the development process means improving the quality of the final product.

The group PEP is a **group-wide required agreement** with descriptions of the highlights as a baseline for management committee product planning and product strategy board meetings. This general **method is shared by all the brands** that compose **Volkswagen Group**. However the brands include their own additional specifications. The following figure shows the timeline of the PEP.

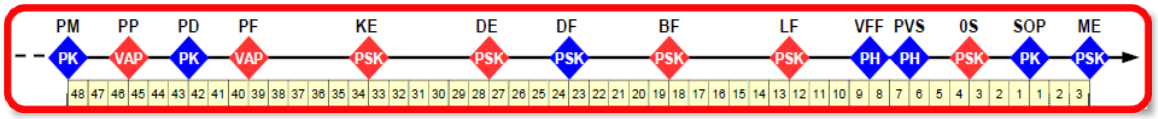


Figure 36: PEP timeline. Source: **Volkswagen Navarra.**

5.1 PM ("Produkt-Mission") – Product Mission

The first step starts **48 months before the SOP (Start Of Production)**. The mission of the product is based on a statement of the objectives, technical characteristics and target client that Volkswagen wants to reach with the new car, in addition to the financial strategy of the brand. In this step a deep study is realized in order to **understand and achieve what the customer wants,** keeping always updated with new technologies, materials and fashions.

The result of this phase is a determined product profile, an approximated position and the **approval of the financial resources necessary** to continue with the new step of the PEP.

This first step of the PEP is directly related with the APQP process, specifically with its first phase (planning and definition of the project). In both cases the customer is really beard in mind for the design and planning of the product concerning their requirements and wishes. It is important to investigate the segment competitors, trying to evaluate how the own product differs from the ones of other brands. The objective is to **determine the different ways in which the product could be improved**, focusing on moving closer to the customer to satisfy their needs. The company wants to know the reasons that lead that the customers purchase the product elsewhere to try to change their opinions and achieve a change of product.

Furthermore, in both cases they also match in the importance of **determining the product feasibility** as well as assuring all the resources required through a deeply defined plan of the product assurance with a team that constantly must review the current contracts with the suppliers helped by the management and logistics support teams.

5.2 PP ("Projekt-Prämissen") – Project Premises

The second phase of the PEP takes place **45 months before the SOP**. The predefined objectives of the project and product are confirmed to achieve an early positioning on the environment and the concurrence coordinated with marketing, technical department,

design, procurement, production, quality and finances as specification framework. There is an important statement of the target direct costs and expenditures and the expected operating income based in a demand study realized.

One of the most important documents of this step is the Requirements Catalogue ("Anforderungskatalog" in German), that is the catalogue developed on the present project. This document is based on a wide variety of technical requirements that the **new vehicle will have to fulfil** afterwards, regardless the model carried on. These requirements or requisites must be achieved in order to avoid previous problems that occurred with old series models or prototypes. However, each of the requirements must be **studied to prove its feasibility**, since it may be possible that the same requisite could be feasible to introduce in one model but for other vehicle could happen the opposite situation. The mentioned catalogue will be widely explained later on.

It is not very difficult to see the similarities between this step of the PEP and the second phase of the APQP (named as: design and development of the product). Both phases are focused on the requirements and specifications that must be performed by the model that will be later on released. The engineers entrusted of the car's design would have to consider all the mentioned requirements to reach the goals proposed and check the feasibility of all of them to solve previous problems emerged.

However, both phases differ in some aspects. Phase 2 of the APQP is thought to perform the assembly of prototypes to analyze them and develop a failure method to avoid problems. Concerning the Project Premises step of the PEP it does not carry out the prototypes assembly and it is not yet the moment to perform that step. The phase entrusted of that mission is the seventh PEP phase, Design Freeze, which is explained with detail later on.

5.3 PD ("Produkt-Definition") – Product Definition

The third phase takes place **42 months** before the SOP and it is called product definition. For its definition, the vehicle characteristics are fixed included the **target technical values** in the characteristics catalogue. The product management assumes the

responsibility of developing the project specifications in reference to the market requirements.

There are some **top/down objectives for incomes, costs and unique expenditures**, in addition to the authorization of the technical description of the product. Furthermore, the volume and price objectives and the first characteristics of the client are stated. One of the most important steps of the product definition phase is the first 3D representations of the vehicle.

Regarding the APQP method, its second phase is related with the third one of the PEP as it happened with the second one, the Project Premises. The definition and drawing of the product mentioned in the current step takes place in phase 2 of the APQP as the engineers are entrusted of developing the product design.

5.4 PF ("Projekt-Feasibility") – Project Feasibility

This phase starts **39 months** before the SOP. To determine the project's feasibility it is necessary to **confirm the project's financial feasibility** of all business areas through the catalogue of agreed objectives and the base of decided valuation for the PD (Product Definition).

Furthermore, the product design goes through a process of **styling selection** in which there is an offer of "n" designs of the exterior and interior of the car and two of the "n" design concepts are selected. The dimensions of a new car tend to change from the previous one so the production line has to be checked deeply in order to verify if the platform is feasible. Also at the same time the **ergonomics concepts are checked** in the assembly line.

In this phase the group has to **decide whether the project is feasible**, if it is, the project follows the rest of the PEP phases. Otherwise the project is cancelled or revised. The target catalogue and the first product's description book are important documents developed in this fourth step.

Trying to find out what phase of the APQP process is related with the current step of the PEP, it is important to see which has something to do with the feasibility of the project,

and that will be the second one, where a team is entrusted of studying every little step of the project to assure its complete feasibility.

The final conclusions of the feasibility study carried out must outline in detail the different **possible scenarios** studied and the implications, strengths and weaknesses of every one. The project responsible team needs to examine carefully the feasibility study and assume the possible **future risks**.

5.5 KE ("Konzept-Entscheid") – Concept Decision

The fifth phase of the PEP, the Concept Decision, begins **33 months** before the SOP. The evaluation of **two final designs from exterior/interior** and the confirmation of the technical feasibility involve the completion of the concept's development with mandatory approval of the prototype.

Moreover, the production times for future steps of the production process plan in **every single work area of the employees is analysed**. Those areas are delimited by blue lines at the beginning and end where the employees will develop the tasks assigned. The industrial planning department have to set the distance between lines according to the times measurement.

The **first virtual prototype** is developed according to the statement of concept characteristics with an estimation of warranties, costs and faults per car. All the concept volume will be transmitted to the project's organisation of the development phase for the series production.

Concerning the APQP process, the current PEP phase is related with phases 2 and 3 of the American method. Phase 2 has some points in common: both carry out the design of the production process to measure assembly times and must confirm the engineering concept and all the feasibility of exterior and interior characteristics of the product. However, phase 2 performs the assembly process of prototypes while PEP's fifth phase is only entrusted of developing the first virtual prototype of the final car. On the other hand, the relation with phase 3 is the importance of reviewing the process system with every step carried out and all the explanations and measurements required in every single phase.

5.6 DE ("Design-Entscheid") – Design Decision

This step happens **27 months** before SOP. In this occasion the objective is to decide the exterior and interior design approach developed and integrated with the according package and technical feasibility. It is compared the actual level of the technical knowledge and it is **concluded the design of the main surfaces**.

For this step a deep study and work of the main design engineers is needed, where they have to reach a design that will be especially defined, with really clear ideas and that should be near to the real final design of the car. They normally have 4 months before arriving to the next step, where the design will be completely confirmed.

As it happens in phase 2 of APQP process, this step is thought to carry out the review of the design to approach to the final design that will be soon decided.

5.7 DF – Design Freeze

The Design Freeze takes place **23 months** before the SOP. In this phase it is concluded the design of all surfaces and details as previous step of the data control. The **status report of product strategy committee** is the **most important document** of this phase. The quality team of Volkswagen works in order to set the quality targets of this model.

In addition, the **first prototype is assembled** 20 months before the SOP. Several tests and evaluations are made to the prototype in order to see what could be improved or what is infeasible and has to be changed. Ever since the first prototype is made, the product is getting closer to what the final product will be.

There are different reasons for doing prototypes, especially when the main purpose is to achieve the best final model. The first intention is to learn from the prototypes how to **avoid probable mistakes or modifications** in the current production process, evaluating each of the steps. It is a continuous method of learning ways to improve the assembly of the car. Furthermore, there can be different types of prototypes that depend on the purpose for which they are thought.

Prototypes are **used for testing and evaluating upcoming designs**. These evaluation cars are built early on during a model year, but with some of changes that are going to be incorporated in the manufacture of the next model.

The new car normally varies its dimensions compared with its predecessor. As a result, it is **crucial to test the production line** and all the processes performed there for the purpose of understanding correctly the modifications that will have to be made in every step. A clear example of this are the hooks that hold and carry the cars through the production line, as it may not be suitable for the new car and it may imply a substantial investment replace it. The fabrication times tend also to change as new features and measures may be introduced to develop correctly all the production line. It is necessary to evaluate every fabrication process and their times.

In addition, the prototypes are also designed to experiment and help to **develop new standards and regulations**, as major safety improvements may be taken into account during the initial stages development of the models, but not removed from current production cars even after the proposed stiffer regulations are rolled back.

To conclude the seventh step of the PEP, it is obvious that it is directly related with APQP's third phase as in both cases one of the main points is the review of quality requirements of the product and process of the model to be performed.

5.8 BF ("Beschaffungs-Freigabe") – Procurement Release

The Procurement Release phase takes place **18 months** before the SOP. In this step the authorisation to **determine the suppliers** for operating equipment is conceded. Also, it is crucial to confirm the production feasibility on prototype basis.

It is necessary to identify the material required for the enterprise and fix the order requirement. The purchase of the needs must be covered negotiating with the suppliers the conditions. In the sheet pieces, the manufacturing of series dies is released. The data is based on the virtual models and the real ones released.

This step is related with phase 4 of the APQP process as in both the suppliers needed to **assume the production of the product** are required to guarantee the validation of the

project. The management and logistics teams will be entrusted of negotiating the entire product required and the conditions of the delivery.

As it says the article “Objectives when negotiating with suppliers “ from the British web page **nibusinesinfo.co.uk**, there are some primary considerations that must be beard in mind when negotiating with the suppliers, including:

- Price.
- Delivery.
- Payment terms.
- After-sales service and maintenance arrangements.
- Quality.
- Life-time costs of the product.

5.9 LF (“Launch-Freigabe“) – Launch Release

The ninth phase, none as Launch Release, starts **12 months** before the SOP. With the launch authorization it is confirmed the **availability and quality of the required pieces** for the adjustment of the product fabrication regarding the market launch planning of the business areas. This launch planning is based on concepts of product, repair and launch variants, as well as presenting the product. The colors, decorative trim and fabric are defined to include them in the PEP’s styling section.

Furthermore, thanks to the launch authorization, the **start of the series-production is strengthened** with the measures definition for possible deviations concerning the initial objectives. The lifecycle planning takes place.

In this case, all negotiations with suppliers that took place in the previous step conclude in the current step with the confirmation of the availability of product necessities, as it happens in phase 4 of the American method. Moreover, in both cases the plan of the production process is controlled as well as the validating the product presentation to approach to final steps of the definitive release of the model.

5.10 VFF ("Vorserien-Freigabe-Fahrzeuge") – Pre-series Release Vehicle

Phase 10 occurs only **8 months** before the SOP. The factory produces the **first vehicles employing the series-installations**, identifying in an early phase production problems, component mistakes, adjustment dimensional precision, etc. to prepare the car for its introduction to the market. The **financial state must be presented** to the PSK that is the product strategy committee.

First and foremost the release for the whole equipment variant takes place, as well as a communication platform, including a communication planning release and a vehicle specification for dealer and after-sales service. The vehicles are called for video filming, photo sessions and press demonstration. **The public can now see what the car is intended to be like**. Before this happens, it is crucial to maintain safely the project with confidential agreements. Finally, the pre-series vehicles are released.

5.11 PVS ("Produktions-Versuchs-Serie") – Pilot Series Production

The PVS, i.e. phase 11, starts **6 months** before the SOP. The configuration matrix of country specifications is developed, calculating the first simulated pricing. It is time to **finish the technical information** with the drawing and data of the final design and the development release.

All the processes concerning logistics are based on **"Just in Time" philosophy**. The first pilot series car is completed. It is necessary to make a test of the function of all individual production means and assembly teams on not-integrated installations of a production line and verify the integrity and plausibility of the pieces list.

Sometimes the **pilot vehicles** are used to **provide the automotive press an opportunity to experience the car** as well as creating publicity and some articles about the models that will appear in showrooms for public view or exhibited at auto shows. However, some models may be destroyed during crash tests. Others are scrapped as they may not guarantee to fulfil safety regulations or emission standards.

5.12 0S (“Null-Series”) – Zero Series

The zero series, i.e. the last step before the SOP, takes place **3 months** before starting the production. The **production and systems means are tested** with integrated series installations on the production process. The process capacity of the service means and test equipment are confirmed.

The **final engineering specifications** concerning the product **are accepted**. The press must be present for the pricing date announcement on trade fairs and events of the press. The materials bill for zero series is set. The employees must learn the characteristics of the new production and the quality assurance and specifications of new product and materials.

5.13 SOP – Start Of Production

After a long way of 48 months of different tests, authorizations, evaluations, studies, production of pilot vehicles and a huge amount of documents and paperwork, the production of the definitive new car starts with a **standardized production process that happens to be the reference statement of the PEP**. All the workers are prepared for the assembly of the new car after some months of preparation and study of all the production process and the assembly line.

This step must carry out the production of the volume of market launch, so afterwards will have to start producing the client demand in the next step.

5.14 ME (“Markt-Einführung”) – Market Launch

Three months after the start of production it takes place the market launch, where the potential customers must have an overview of the vehicle, so it is essential to have a constant communication with the market. The management of the series volume requirement takes place and **the new product is launched to the global market**.

Once the final model is launched to the market the brand has to keep under review the satisfaction of the customers with their product to know if the clients are satisfied with the car and if not, investigate what should be done to please their wishes and necessities to avoid making the same mistakes in the future. That is a **process of feedback concerning the customers** to find corrective actions to solve their disagreements and it is completely related with the fifth and last phase of the APQP process as it carries out this mentioned feedback as its main output.

6 REQUIREMENTS CATALOGUE

This point of the memory is the most important one of the project, since the main purpose of the project is, after all, develop the generic requirements catalogue of product. Thus, it is essential an **in-depth explaining of the development process performed**, as well as the tools employed and the different sources consulted to carry out the catalogue. Down below each step of the catalogue mentioned before is explained with detail, **with clarifying screenshots of the program** in different situations to show how it works and some examples of each consulted source.

6.1 Introduction and objectives

The requirements catalogue is the result of **4 months of work, investigation and development** of a clear idea, which is to standardize the technical generic requirements to be fulfilled by a new model so it enables and **speeds up the work of the design engineers**.

The idea is specially to **avoid mistakes that were made in the past** or to continue some methods that produced good results establishing the "obligation" of doing it the same way and not change non-problematic processes. It is very easy to see the errors and from then on start to study how to avoid it concluding with one solution that should be established in order to improve the quality of the product. However, it is not so easy to understand what methods are correctly implemented but could finish leading to future troubles if those methods are not standardized and imposed to guarantee the continuity of the process and its better speed, quality and less future costs.

To sum up, the main objectives that the requirements catalogue is thought to achieve are the following:

- Avoid and solve problems emerged in previous models.
- Ensure the continuation of successful assembly methods and concepts.
- Standardize and reduce product variants.
- Propose modifications of assembly concepts.
- Reduce cycle times.
- Improve the ergonomics and safety of the workers.
- Reduce costs.
- Avoid re-working pieces.

The majority of the catalogue points have been **developed thanks to previous errors or problems emerged in prototypes or final series models** so since then a new requirement is forced to be performed to solve those troubles, avoiding they appear in the future. Such solutions to the problems tend to be modifications of product, process and so on to solve the concerns that previously emerged.

However, not all the catalogue points rise from problems with previous models. Some points emerged from the **dialog with experts of the different areas** involved in the development and manufacturing of the VW Navarra models so they have been asked for new requirements to have into account in the design of pieces or joining elements, the improving of assembling and production processes or the elimination or substitution of previous methods or products implemented in models of the current factory.

6.2 Catalogue points selection

When deciding to select the points for the requirements catalogue it is necessary to **resort to diverse sources available** that have been consulted: points of old requirements catalogues for concrete models, points studied nowadays by the working group of concept analysis, weekly meetings concerning problems emerged on the prototypes or series models, etc.

6.2.1 Former catalogues

Currently some requirements **catalogues of concrete models** are available. However, the catalogue to be developed in the present project must consist on generic requirements or requisites, so any future model must achieve them. Therefore, many of the points of old catalogues of concrete models are very specific of those models and are not valid for the generic catalogue. Ultimately, the purpose was to **find out those points that were applicable to the catalogue**, so every model must be carried out following those requirements.

The consulted catalogues were those of the Polo A05, A05GP and A07. The requirements of those catalogues are **organized by groups referred to the different specialities** entrusted of the car's production as car body, engine, electric group, etc. Inside them, there are different sets or subgroups charged of more specific areas of the car. For example, inside the car body group there are several subgroups such as sheets and presses, painting, bumpers and crossbars, or doors, among others. Each point of the catalogues carries a numbering inside each group and a title explaining the point. Furthermore, the problem emerged previously is explained, clarifying the car area where it was produced, and after a solution or requirement is proposed in order to solve the mentioned problem so it won't be repeated. Lastly, each point tends to be accompanied by some clarification pictures and the name of the person that carried out each catalogue point.

If a problem wasn't still clear, the next step was to talk with the expert that carried it out in due course. Most of the time, this was the final solution to finish to understand the mentioned point. However, sometimes the expert was not available and was necessary to find out another specialist of the area to ask for an explanation.

Regarding the language version of the catalogues, there were drafted in German, so the difficulty to understand their points was higher as the great majority of their content comprises technical words. Thus, it was necessary a first **familiarization with that vocabulary** at the beginning of the internship to be able to translate correctly the convenient points to the English language. To have an idea of the type of points extracted from the old versions of requirements catalogues, some examples are shown hereafter.

-Example 1:

The first example described is related with a problem emerged in previous models in the assembly line, more precisely in the **doors line**, which takes place in the Engine shop. In that workshop there were some difficulties with the **fixing of the front side window seal** (that is assembled in every door) into the rear part of the A-pillar's sheet guide. The operator had to make a big effort to succeed with the assembly, involving a **big waste of time** as well as ergonomics conditions for the employees. A picture of the side window seal introduced into the sheet guide is shown down below.

Figure 37: Side window seal into the sheet guide.
Source: **Former catalogues, Volkswagen Navarra.**

The wish was to find out a solution to ease the assembly of the side window seal into the sheet guide and the specialists decided that it was necessary that the side window seal **came lacquered from supplier** so it enabled an **easier entrance** of it into the sheet guide. This involved that the ergonomics would be improved and an important reduction of cycle time.

-Example 2:

The second example of a point extracted from previous requirements catalogues is related with the **airbag control module**. The housing for that module used in the latest

series production Polo model, the A05GP, didn't cover the entire connector base, as it can be seen in the following picture. This caused that the connector allowed the entry to the control module with an inclination angle so the **pins** of the control module **could bend and break**.

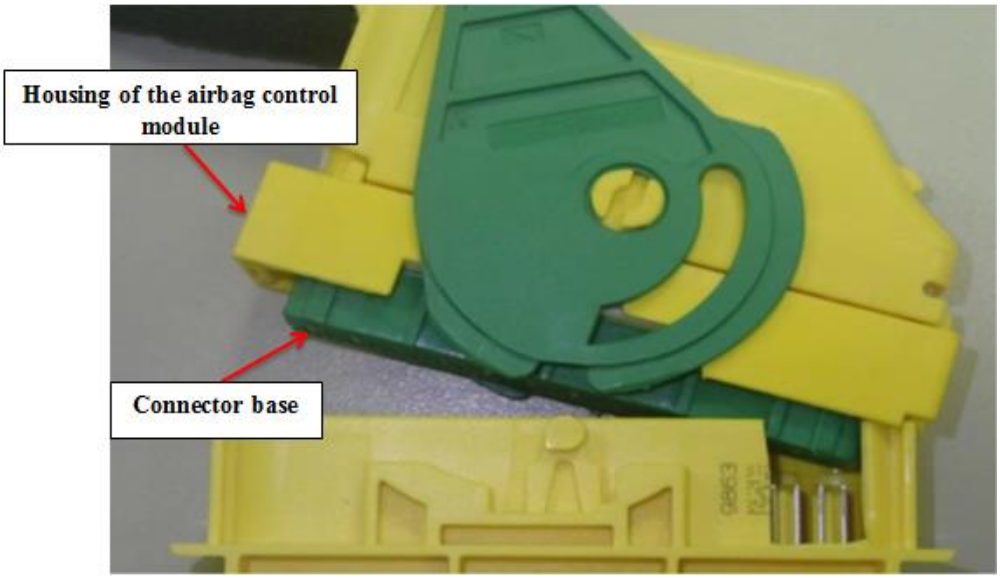


Figure 38: Polo A05GP: airbag control module.
Source: **Former catalogues, Volkswagen Navarra.**

The solution was the new concept of the airbag control module that was going to be introduced in the new model of the VW Polo that will be launched next year, the Polo A07. In this new concept, the **housing covers the entire connector base** to avoid that the connector base connects to the control module with an inclination angle. This new concept should be the new requirement to solve the previous emerged problem. The following picture shows the new concept of the airbag control module.

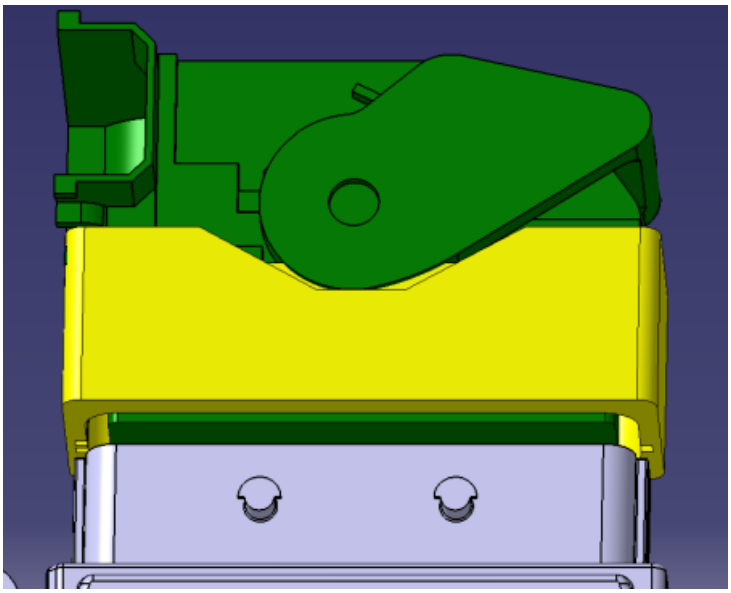


Figure 39: Polo A07: airbag control module.

Source: **Former catalogues, Volkswagen Navarra.**

-Example 3:

The third example that is going to be described affects to the **rear window's heating** of the vehicle. In the Polo A05GP, the connection of the heating is made through a wiring connection by both sides of the tailgate border and needs afterwards an additional assembly from 2 connections as well as two caps to cover the connections. The issue here is to **improve this assembly concept** as it is quite complicated to carry out and the production time could be substantially reduced. In the following picture it can be seen one of the caps that cover the connections at the tailgate border.

Figure 40: Rear window's heating: cover cap at the tailgate border.

Source: **Former catalogues, Volkswagen Navarra.**

A better assembly concept of the rear window's heating was picked up from the **concept employed in the Opel Corsa**, where the connections are **directly fixed without intermediate connecting pieces**, covering afterwards the components with the tailgate lining, improving the assembly conditions and reducing the cycle time. From then on, this concept should be guaranteed for next vehicles generations. The picture down below shows the described concept.

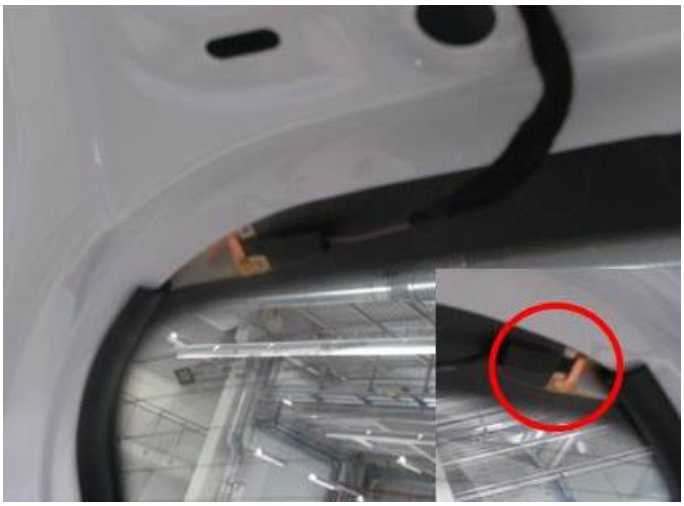


Figure 41: Opel Corsa's assembly concept.

Source: **Former catalogues, Volkswagen Navarra.**

-Example 4:

In this example, there was a problem concerning the air conditioner, specifically the **bushes of the compressor**. In the assembly line, the bushes are fixed to the compressor by pressure, but sometimes they fall during the assembly of the compressor and the introduction of the screws. In the following picture it can be seen the different pieces that compose the mentioned assembly.

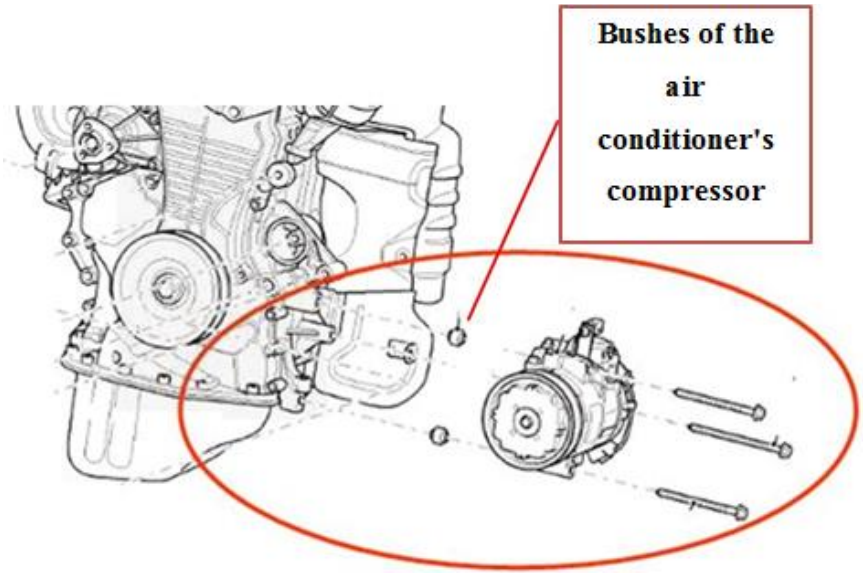


Figure 42: Air conditioner's compressor.

Source: **Former catalogues, Volkswagen Navarra.**

To solve that problem, the requirement to be introduced in the catalogue had to say the following: "Ensure that the **bushes are part of the compressor or its bracket**". That means that the bushes would be removed as a single piece, being now part of a bigger piece.

6.2.2 Concept Analysis

Another consulted source for the development of the catalogue and the introduction of requisites into it was the labour performed by the employees that take part of the **working group of Concept Analysis** day by day. This group belongs to the organization chart of product's technical area and is in charge of **documenting the different problems that emerge** on the vehicles, focusing currently on the first

prototypes of the new Polo model, the A07, which will be launched next year, and trying to discover the best solutions to every concern. The problems mentioned can be troubles of the assembly of pieces, wrong connections, water or fumes entries emerged on the test centre, etc. Those problems are **documented in one shared file** inside the department so every engineer of the area has access to all documentation to review or update the statement of all of them. Most of them are not closed at all because they need a final validation of the head of the department or because the solutions are not always possible to achieve, so they can be modified.

After the local final validation, it is required a last validation concerning the headquarters in Wolfsburg's factory. The main responsible of each solution must inform the counterpart department in the mentioned German factory that will be entrusted of studying the proposed solution to confirm its feasibility. If the solution is confirmed, the modification of the product or process will be introduced to avoid that the previous problem emerges.

During the internship experienced each of the documented points of the mentioned file were studied, avoiding those problems that were very specific of a concrete model and not applicable to the catalogue of the present project. The points that were feasible to be introduced into the generic requirements catalogue were dealt with some of the specialists of the analysis concept group to think about the possible solutions to the troubles to figure out the final requirements that have been recently introduced in the "Anforderungskatalog". Those solutions led to the requirements necessary to avoid repeating the emerged problems.

To understand better the kind of problems that Concept Analysis team had to solve, some examples are described down below.

-Example 1:

For example, some documents studied from Concept Analysis dealt with the following problem: there were **holes between sheets that were not perfectly covered** with an insulating material so the leak tightness was not completely guaranteed and it involved

entries of water and fumes that passed through those holes and covered the space between sheets. The following picture shows the mentioned problem.

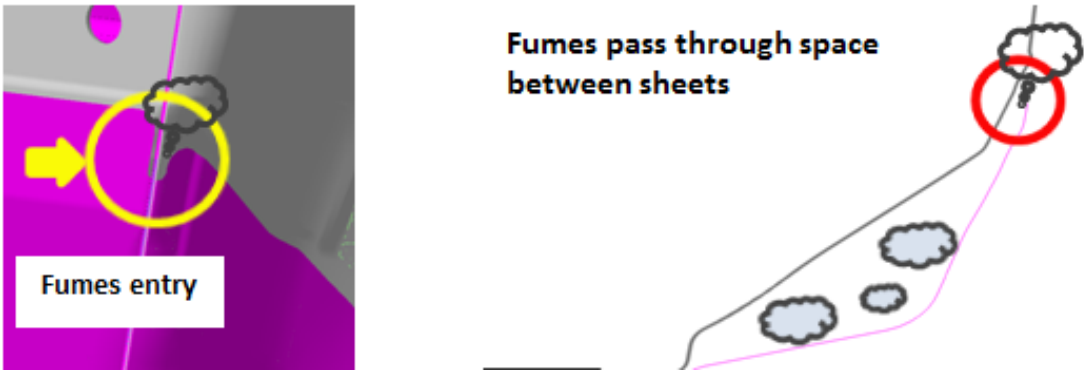


Figure 43: Fumes and water leaks. Source: **Concept Analysis, Volkswagen Navarra.**

Those leaks involve that the car will have future problems of corrosion and will not pass the quality tests. Next step was talking with a specialist of Concept Analysis team to think about the requirement that should be guaranteed to avoid those leaks that lead to corrosion problems and to write it into the "Anforderungskatalog" so it would be one requirement to be fulfilled. The conclusion was that the required point of the catalogue should say: "**Ensure** that in the joints there is **complete leak tightness through sealing filler or welding**". With that requirement the problem should be solved. This problem should be cleared up by the commissioned of Body shop if the solution is welding the problematic zones or by the one of Paint Shop if the final solution is ensuring the leak tightness through sealing filler or if the weld fails to guarantee the complete sealing of the holes between sheets. In any case, the commissioned entrusted of solving the mentioned problem should always be **in contact with the Quality department** to make sure that all the quality requirements are fulfilled so the car will pass without any problem the quality tests.

-Example 2:

Another example of a problem that the team of Concept Analysis was concerned about was the following: the **joints of the cooling pipe support of the heating circuit stayed pinched** in the assembly process. This involved that in the heating circuit some leaks

appeared. Furthermore, the directions of the connecting pipes of the heater joints were not always completely clear for the operator. The following picture shows the problem with the joints.

Figure 44: Joint of the cooling pipe support gets pinched.
Source: **Concept Analysis, Volkswagen Navarra.**

After talking with a member of Concept Analysis team the solution to the mentioned problem was the following: modify the assembly concept. The modification involved **removing the cooling pipe support**. The new concept should ensure that all connections with the heater joints should be carried out through **fast-connections**, guaranteeing that the directions of the pipes are the correct and completely clear for the operator.

-Example 3:

In many cases, the problems concern mistakes of the operators because the locations or situations of some pieces or connections are not completely clear. That's the case of the **windshield wiper's tank pipes**. Those pipes are sometimes **incorrectly connected** at the assembly line because its dispositions can cause a wrong assembly by the operator as the lengths of the pipes allow that mistake. To understand that situation, a picture is showed down below clarifying the problem.

Figure 45: Windshield wiper's tank pipes (before).
Source: **Concept Analysis, Volkswagen Navarra.**

The problem was discussed by some members of the team of Concept Analysis and the solution was to make something that is commonly known as **"Poka-yoke"** that is a Japanese term that means "mistake-proofing". It consists on a mechanism that ensures that the operator won't make a mistake. The purpose is to remove product defects and **avoid human errors** and it is very used in the automotive industry. This is not the unique requirement of the developed catalogue consisting on a "Poka-yoke" as there many points like the current one.

Ultimately, the requirement agreed to be fulfilled was the following: ensure the correct disposition of the pipes so their lengths **don't allow a wrong assembly by the operator** ("Poka-yoke"). Thus, the problem would be solved. The taken solution is shown in the following picture.

Figure 46: Windshield wiper's tank pipes (after).
Source: **Concept Analysis, Volkswagen Navarra.**

As it can be appreciated in the picture, the disposition of the pipes allows the correct assembly of them, avoiding that the operator makes a mistake as the pipes lengths and disposition allow only one possible solution.

-Example 4:

Another problem emerged was about the **accumulation of water in the water box**, that is a piece situated in the front part of the car and, as the name says, has to evacuate the water that accumulates when it rains. However, sometimes the evacuation holes were **not capable of evacuating all the water** due to the big accumulation of it. When the car was in movement, the accumulated water got to the centre zone of the water box, getting through the cockpit and ending in the air vents of the heater. To understand the mentioned problem, down below two pictures are shown: the left picture shows the water accumulated at the water box while the right one demonstrates the problem of the entry of water at the air vents.

Figure 47 and 48: Water accumulated at the water box and air vents.

Source: **Concept Analysis, Volkswagen Navarra.**

Finally, to solve this problem, the requirement to be fulfilled was the following: ensure **a grid zone with enough holes at the centre of the water box** to guarantee the complete evacuation of the water. Furthermore, the air entry grid of the heater must be covered with a protective cap to avoid the entrance of water and dirt. To see the implemented solution the following picture is shown.

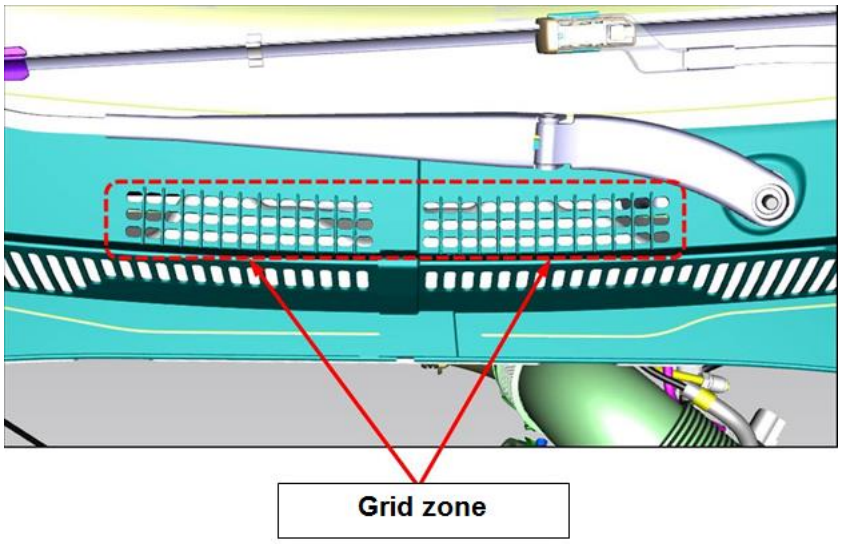


Figure 49: Grid zone of the water box.

Source: **Concept Analysis, Volkswagen Navarra.**

6.2.3 Weekly meetings

On the other hand, every week diverse meetings were carried out at the technical area department, having attended to a big number of them to understand in a better way some matters related with the vehicles assembly, to familiarize with the technical vocabulary employed and to know some specialists of different working areas.

Every day early in the morning it was made a **meeting at the Try Out centre**, where the assembly of the prototypes of the Polo A07 took part. The people involved in this reunion were the leading responsible of the assembly of prototypes as well as some specialists of different departments and people in charge of logistics, test centre, residues management, etc. In stated meeting they talked about the **status of the prototypes** that were being assembled one by one, explaining with detail the diverse problems that appeared the day before this daily reunion, involving problems with assembly, mismatch of some pieces, pieces missing or breaking, etc. Thus, the logistics responsible had an important role taking charge of the constant disposition of the necessary pieces. Each of those problems were documented and saved in a shared file so all of the people in charge of the prototypes had access to it, and they had to deepen in every single one in another meeting that took part every Tuesday, which is explained widely later on. Concerning the Try Out's meeting, this event was important to comprehend every detail of the troubles emerged because each of them could be seen visually to have more information of all of them apart from the available documentation.

Concerning the Tuesday's meeting, named as **"Vorklärungsrunde" (round of primary treatment)**, it was carried out at the measurements room, involving the previous problems that happened last week. Every problem had to be documented by the complainants who saw the problem emerged. All those documents were constantly sent to the responsible of "Baubarkeit", that is more or less the installation capability, who organized them by car areas and sent each problem to the department or group involved in such car areas. All the different **problems were saved in a list named "Streifenliste"**, which is like a "To do list", where each of them was numbered to make an easy tracking and monitoring, having linked the rest of the information of any problem saved in other files with pictures, studies and so on. Each department had to

deepen in every problem to find out its reasons and to think about possible solutions that will be later on discussed on the Tuesday's meeting. The problems involved opening some problems sheets to analyze technically every trouble and to see the progress of them. When a solution was agreed, it had to be sent to the headquarters in Wolfsburg where some specialists would study the solution presented and accept or not its feasibility. If it was accepted, an **ÄKO** was announced, that is, a **product modification** was needed in order to achieve the problem's solution. In order to understand what kind of problems that daily emerged in the assembly of prototypes at the Try Out centre, some examples are going to be explained with clarifying pictures.

-Example 1:

The first example described talks about a problem that happened with the **telescopic**, that is a **piece from the steering column** that is assembled near the pedals that the driver always uses. In previous models, the position of the telescopic was in such a way that didn't produce any problem. However, in the prototypes this piece was positioned inverted regarding the series version, causing sometimes hand damage to the workers when they were assembling it. The telescopic has two cylindrical parts, one of bigger diameter than the other one so it one can slide during the assembly. In the previous version, the part of bigger diameter was below, while in the current one it is above, allowing that in the assembly this one could go down and **pinch the worker's hand**. In the following picture it can be seen the telescopic and the hand damage that happened.

Figure 50: Steering column's telescopic.
Source: **"Streifenliste", Volkswagen Navarra.**

To avoid this **high risk of damage**, the requirement to be introduced in the catalogue and fulfilled afterwards should be: "Guarantee that the position of the steering column's telescopic is safe for the employee to avoid any damage". With that requirement the mentioned problem would disappear.

-Example 2:

Next example is related with documentation about the "Fugenplan", that is the **adjustments plan**, where each piece and set has documented how the pieces must be assembled and the limits in terms of adjustments. The problem was that, in some cases, there was a **lack of information** on the "Fugenplan" **regarding clearances and symmetries**. Regarding the picture down below, where the right side of the cockpit can be seen, the adjustments plan didn't say anything about the limits of clearance on the X axis and the symmetry between sides (A-pillar and cockpit).

Figure 51: Right side of the cockpit.
Source: **"Streifenliste", Volkswagen Navarra.**

To solve it, it should be required that all the parameters concerning **clearances, tolerances and symmetries** were **completely defined** in the information about pieces setting to avoid bad quality settings because the Quality department would not pass some settings and the future client could complaint about that.

6.2.4 VFF – problems sheet

Continuing with the consulted sources for the introduction of requirements into the catalogue, an important source was an **Excel sheet that stored all the problems and modifications** that emerged in the VFF of the previous Polo model. The VFF, as it was explained recently in the fifth section were the PEP process and all the steps are described, is one of the last steps of the PEP and carries out the release of pre-series vehicles.

The process chosen was starting to talk with the different specialists that were responsible of following, monitoring and supervising the points that were introduced in the problems sheet. In those meetings, the **decision-makers decided which points were feasible to be introduced** in the requirements catalogue and what would be the requirement to be fulfilled in each case. Some of the points extracted from the VFF problems sheet are shown down below.

-Example 1:

One example of a problem taken from the mentioned problems sheet was about was the following concern: during the **assembly of the tailgate's lining** it was necessary to **fix the clamps** that join the lining to the tailgate **one by one**, with a non-ergonomic position and needing to push really hard to complete the assembly. It was necessary to improve the working conditions for the operators. The following picture shows one of the fixing clamps.

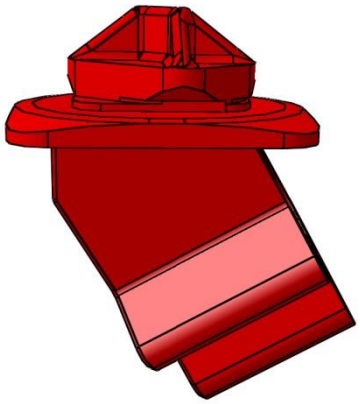


Figure 52: Tailgate lining's fixing clamp.
Source: **VFF problems sheet, Volkswagen Navarra.**

After talking with the correspondent member of the mentioned problem the solution that was taken to solve it was the following: **modify the assembly concept**. The lining would be **supported by a fixing tool** with the tailgate completely opened. Later on, the operator would start to close the tailgate until it reached **the supported lining** that will be **directly fixed to the tailgate** as the clamps will be much easier to get introduced. With this solution, the ergonomics problem would be solved as the effort that the operator would have to do to introduce the lining into the tailgate will be significantly lower, improving a lot the working conditions.

-Example 2:

The problems sheet had documented many problems with an important piece to cover the interior of the car's body, the lining. The **fixing of the lining of A, B and C-pillars** has been always complicated due to the absence of vertical reference to support the lining when assembling it. This involved **bad conditions of the workers' ergonomics** and important increases of the production times due to the necessity of re-working the mentioned linings to ensure the perfect fixing.

To improve the working conditions, reducing the toughness to assemble the linings, the requirement to be fulfilled from then on must be the following: **ensure Z-axis reference** of the linings of the A, B and C-pillars, as well as guaranteeing that the lining's centering allow an easy assembly, with some **flaps of easy entry**, as it can be seen in the picture down below.

Figure 53: Flaps of easy entry at the pillars linings.
Source: **VFF problems sheet, Volkswagen Navarra.**

6.2.5 Contacts round

One of the most important sources that were consulted to obtain new points or requirements for the catalogue was the contacts round kept with some **specialists of the different workshops** involved in the production process of the VW Polo. Those people had much experience in previous launches of Volkswagen Navarra, so they possessed very precious information about the problems they first-hand experienced in previous models and that, in some cases, could still be solved with a better and improved solution. Of course, they also were interested on keeping some assembly processes that gave good results and should not be modified at the moment.

Some visits were made to the different assembly lines of Body shop, Paint shop, Engine shop, Door's line and others to see with the help of the specialists everything that could be improved, verifying how it was possible to improve the ergonomics of the workers or how to avoid confusions of the operators that could lead to assembly mistakes.

To better understand the kind of requirements that were extracted from the contacts round with the experienced personnel of the different workshops, down below some of the example points that have been introduced into the generic requirements catalogue are described.

-Example 1:

The first example talks about a point that is not a problem at all but it involves an assembly process that could be improved. In the door's line, the lower fixing of the **door's lining panel** of the Polo A05GP (the last Polo model launched to the market) is assembled **through a screw and a nut** where the sheet has a **forming zone**. A picture of the described zone is shown.

Figure 54: Polo A05GP: sheet's forming zone and hole for screw and nut introduction. Source: **Contacts round, Volkswagen Navarra.**

This assembly concept involved a non-ergonomic and slow work of the operators. To improve it, the specialist of door's line wanted to remove it and introduce the assembly **concept used in the Volkswagen Golf**, where the lower fixing of the door's panel is **directly fixed to the door with a clamp**, avoiding the sheet's forming zone, the screw and the nut. To understand this concept, hereafter a picture is shown.

Figure 55: VW Golf: clamp that fixes the door's panel at its lower zone.
Source: **Contacts round, Volkswagen Navarra.**

-Example 2:

A similar example extracted was also extracted of the talk with the door's line specialist. The current assembly concept (Polo A05GP) of the **exterior mirror's interior cover** was the following: the cover was **fixed to the front doors with a screw and a rubber block**. The F-time employed by the operators was a bit high and the specialist wanted to reduce it.

A new concept was already being introduced in the prototypes of the new Polo model that will be launched next year. In this new concept, the **rubber block and the screw were removed and substituted by clips that fixed directly the cover** to the front doors, so they joined easily and with less effort of the workers and reducing significantly the cycle time. This idea had good acceptance by the main specialist of the area and wanted to introduce it from then on in the requirements catalogue to be fulfilled by next models to be launched.

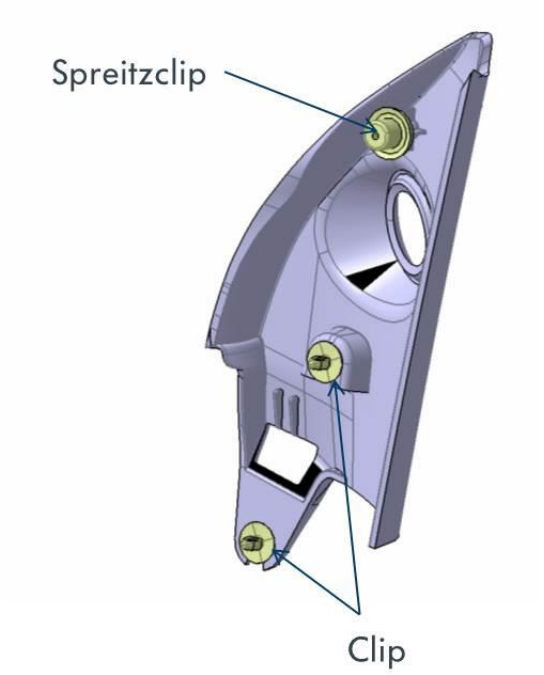


Figure 56: Polo A07: assembly concept of the mirror's interior cover.
Source: **Contacts round, Volkswagen Navarra.**

-Example 3:

The third example was defined also at the Engine shop, but in this case it is related with the chassis frame, specifically the front chassis frame. There is a piece called **pendulum support** that is thought for the articulated fixing of chassis pieces and has a **key sticker with its reference and bar code** that a camera must detect to read all the information of the pendulum support and know to what car it corresponds. The problem was that the **supplier didn't define a plane for the key sticker**, so it didn't come attached exactly in the same point and the camera sometimes didn't detect the sticker and gave an error, delaying the assembly line. Down below a picture with a pendulum support with its key sticker attached is shown.

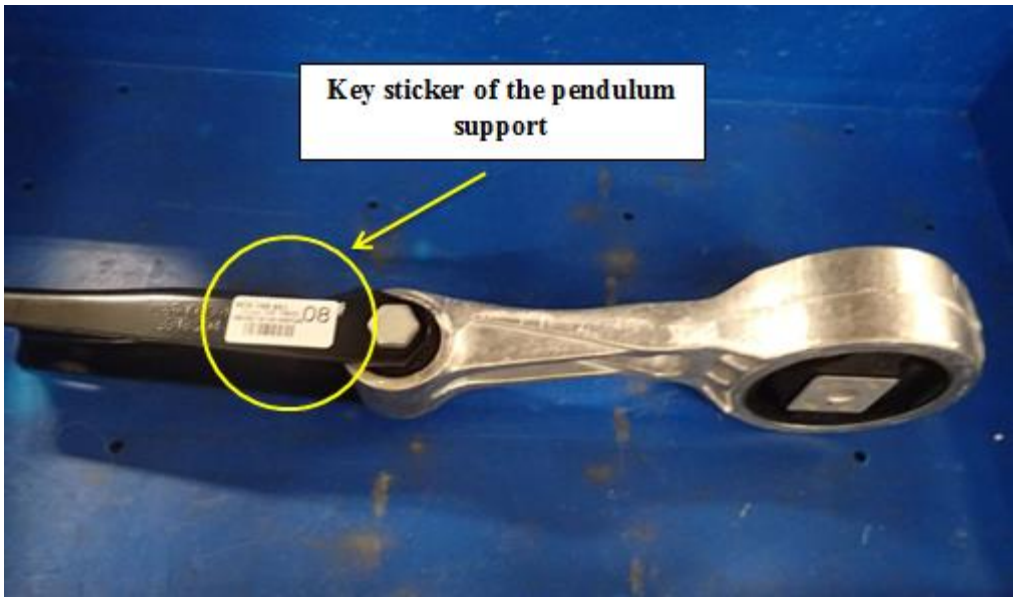


Figure 57: Pendulum support.

Source: **Contacts round, Volkswagen Navarra.**

To solve it, the specialist told that the requirement should say the following: "Ensure that the supplier defined the plane of the key sticker of the pendulum support so all of them come with the **sticker in the same exact place**". Like this, the problem would be solved and the camera's error would be completely avoided.

-Example 4:

Another interesting point extracted from the Engine shop, but in this case from the door's line, is related with the **lining panel**, specifically the one **of the front doors**. The assembly concept of that panel is through a pin that gets inside the interior cover of the mirror from the bottom to the top, which is the **orientation of the pin**. A picture is shown down below to understand the assembly concept.

Figure 58: Front door's lining panel, pin's current orientation.

Source: **Contacts round, Volkswagen Navarra.**

The problem is that the bar panel tends to get pinched due to the pin's orientation, causing a tough assembly to the workers, worsen the ergonomics at the assembly line. The best solution found out was to ensure from then on that the orientation of the pin goes **from the top to the bottom** (upside-down as currently) so it can be assembled by this way, **avoiding that the panel gets pinched**, reducing the cycle time and improving the ergonomics of the operators.

6.2.6 "Produktklausur"

Last but not least, an important consulted source was the "Produktklausur", which is a meeting that usually happens twice during the PEP process of each car. It involves the **presence of heads of different departments** that are informed about the product modifications and innovations that will be further on introduced on the new model. The specialists of each area involved in the modifications present the car updates and all they carry.

Some of the modifications presented in the "Produktklausur" were **technological innovations** that can be feasible to be introduced into the requirements catalogue, but there also were basic modifications to improve the assembly of some pieces, the cycle times or the ergonomics of the operators, among others. The mission was to study several documents of the mentioned meeting to speak with some specialists that know more about the modifications introduced and told the most important ones to be introduced into the catalogue.

Following the current paragraph, some examples are described to show the type of modifications introduced in the "Produktklausur".

-Example 1:

The first example describes a **collision problem concerning the rear camera of the car**. More precisely, the collision was between the rear camera's wiring and the rear bumper, as in this model the rear camera is situated in the emblem zone. This trouble involved the **introduction of additional brackets to avoid the collision**. The F-time was highly increased due to the different bumper variants that could carry a mistake of the operator, with the subsequent costs rising. The picture shown down below clarifies the wiring collision.

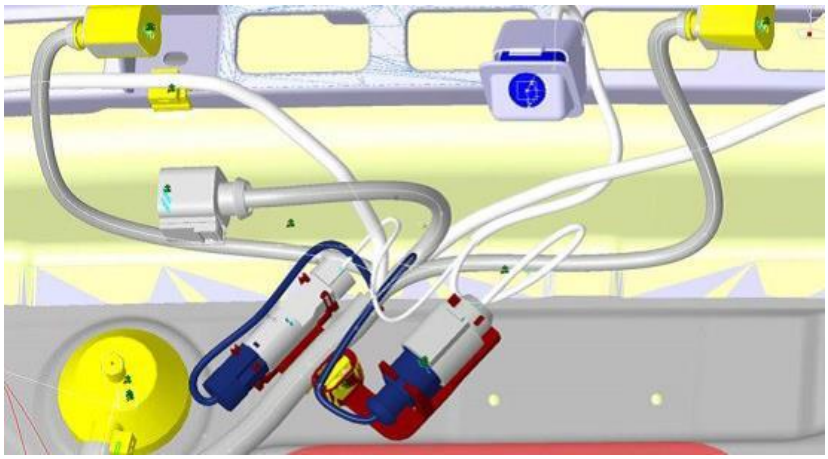


Figure 59: Rear camera's wiring.

Source: **"Produktklausur", Volkswagen Navarra.**

To solve the mentioned problem, the solution was to **integrate the rear camera's wiring into the tailgate wiring**, guaranteeing that the rear camera was situated somewhere tailgate's area that avoids wiring collisions. This idea also involved the reduction of bumper variants. The following picture is shown to understand and see with detail the introduced modification.

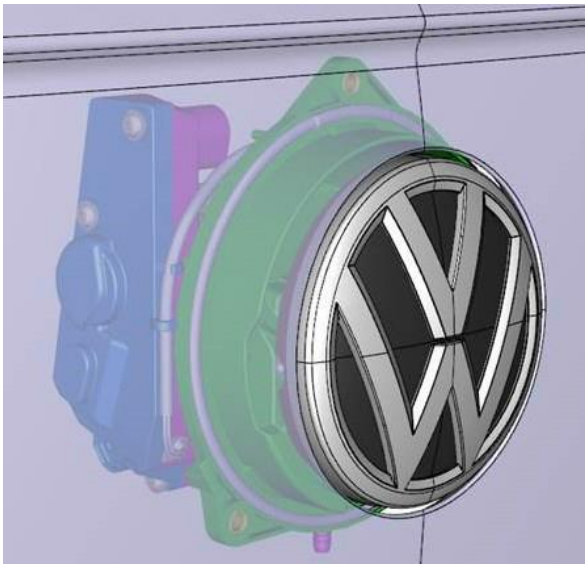


Figure 60: Rear camera's new location.
Source: **"Produktklausur", Volkswagen Navarra.**

-Example 2:

The second example of a product modification of the "Produktklausur" dealt with the following problem: the **assembly and disassembly of the windshield wiper engine** and the wiring of that area was really complicated and not ergonomic due to the geometry of the windshield crossbar as it was completely straight without a zone to ease the manual access.

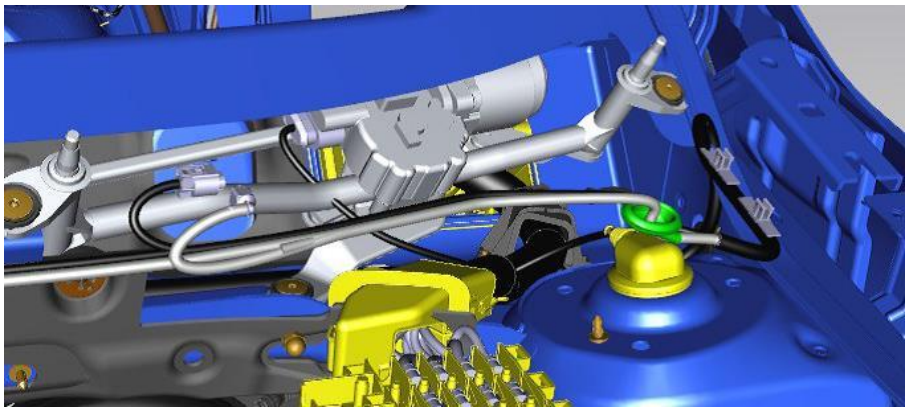


Figure 61: Windshield crossbar (before).
Source: **“Produktklausur”, Volkswagen Navarra.**

To solve that problem, the modification introduced and presented in the “Produktklausur” was to ensure that the windshield crossbar had a **cut or an open area to guarantee an easy assembly and disassembly** of the windshield wiper engine and the correspondent wiring. Hereafter a picture is shown with the imposed solution.

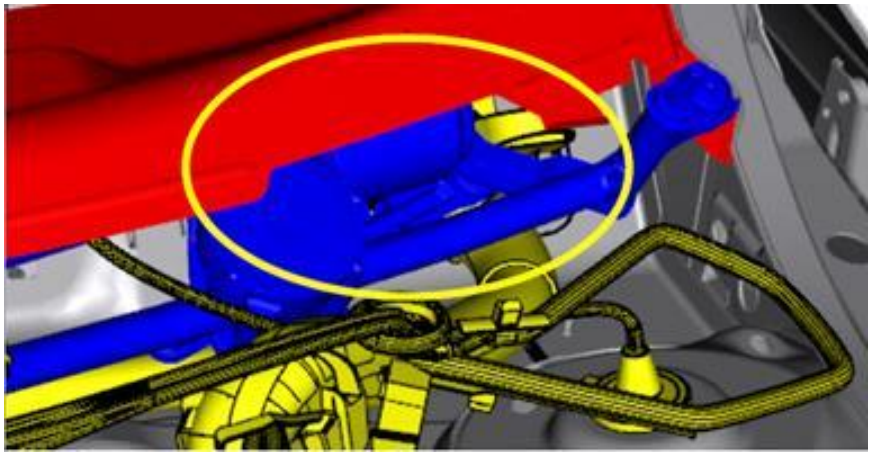


Figure 62: Windshield crossbar (after).
Source: **“Produktklausur”, Volkswagen Navarra.**

6.3 Introduction of new points – GESPRO

The tool employed to introduce and save the different points of the requirements catalogue was GESPRO, an informatics program described widely down below, explaining its function, characteristics and other aspects to take into consideration.

6.3.1 GESPRO – What it is?

GESPRO is an **internal program of VW Navarra** developed and managed by the department of Technical Office. The GESPRO program is essential for the development of the present project. It consists on a **big data base of the different problems** reported by the employees of the Polo models produced at the Volkswagen Navarra's factory. From these troubles it started to appear the old versions of the requirements catalogues as catalogues and GESPRO problems present the same format, that is to say, firstly the problem is presented and explained with detail (where it occurred and its cause) and, afterwards, a solution is proposed to solve the concern.

The purpose of the program is, after all, dispose of o**ne single tool to focus all the problems in a simpler and intuitive way.** Each problem is reported to the person charged of saving them, so he assigns each of them to one "Fachgruppen" or FG, that is, to one professional group or section that will have to manage the trouble.

At the beginning of the program each user (it has to be authorized with user and password) will always find a panel with the new information about the status of the problems reported and/or the existence of new problems to solve. The following picture shows the news panel.

Figure 63: News panel. Source: **GESPRO, Volkswagen Navarra.**

6.3.2 How does it work? FG and Sets

As it has been mentioned previously, the FGs are the groups entrusted of the management of the different problems. **Each FG** or "Fachgruppen" **is divided** in turn **into some Sets, concerning more specific areas** of the model. Thus, each FG must assign the problems to the related Set so it looks after the problem with a deep control, introducing it into GESPRO.

Currently 5 FG exist with their corresponding Sets:

- "Ausstattung" (outfit):
    - A1: centre console, plastic components of the cockpit…
    - A2: airbags, seat belts and security components.
    - A3: seats (except electric connections)
    - A4: interior linings (sound isolating, car boot, carpet…).
    - A5: refrigerating system (air conditioner pipes, compressor…).
    - A6: doors linings.

- “Karosserie” (car body):
    - K1: presses and sheets.
    - K2: painting.
    - K3: bumper, crossbars…
    - K4: exterior equipment (spoiler, wiring…).
    - K5: bonnet and boot (except wirings and linings).
    - K6: doors (wing mirrors, windows, power window, except wirings and linings).
    - K7: headlights, rear lights, brake light, fog lights).

- “Elektrik” (electric):
    - E0: electronic components.
    - E1: wirings (alternator wire, doors wiring, boot wiring…), connectors, brackets and guides for the wirings, battery consoles…
    - E2: radios, speakers, antennas, impedances, USB, Aux-In…
    - E3: doors switchboards, keys and push buttons, rain sensor, lights control…
    - E4: energy system.

- “Fahrwerk” (chassis frame):
    - F1: front chassis frame (sub-chassis, dampers, tie bars…).
    - F2: steering system (engine, steering rack, except wiring).
    - F3: brake system (pipes, brake pads, ABS pump…).
    - F4: rear chassis frame.
    - F5: fuel pump, tank, flume, fuel pipes…

- “Aggregate” (power equipment):
    - M1: petrol engines (except wiring).
    - M2: diesel engines (except wiring).
    - M3: refrigerating system (engine compartment pipes).
    - M4: gearbox, Start Stop, clutch, towrope…
    - M5: engine switchboard, alternator, starter engine…
    - M6: exhaust system (exhaust pipe, etc.).

To show the main window employed in GESPRO with its correspondent fields to be fulfilled the following picture is showed.

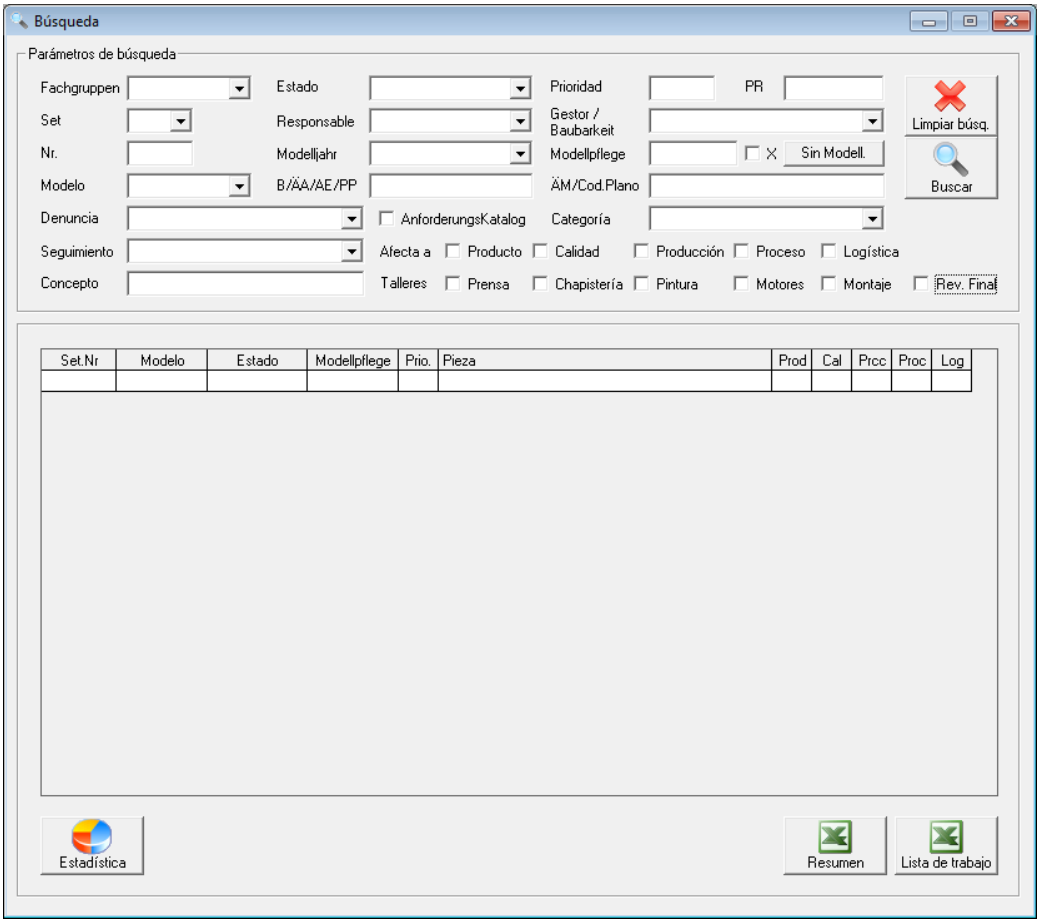


Figure 64: Search window. Source: **GESPRO, Volkswagen Navarra.**

Once it is clear to which Set is related every trouble, the **person charged of its management must introduce it in GESPRO**. To that end, some compulsory fields must be complimented, starting with the car version (field "Modelo") correspondent (Polo A05, A05GP, A07…) and the Set it belongs to. When assigning a Set, the **program generates automatically a structure of files** on the GESPRO server where all the annexes that may be found convenient to clarify the problem and the tracking of its resolution will be saved. Hereafter, the title and description of the problem are written, with some pictures and/or documents attached for a better understanding of the trouble. The **priority of the problem is established** setting a "1" on the correspondent checkbox if it is a primary issue that requires special attention or a "2" if it is not an especially urgent theme.

There are other fields that must be fulfilled such as the responsible, the status of the point, the category, the manager, etc. Moreover, it is important to **highlight the areas and workshops affected**, that is, if it affects to product, process, logistics, quality or production and if it affects to press shop, body shop, paint shop, engines shop, assembly shop or final assembly.

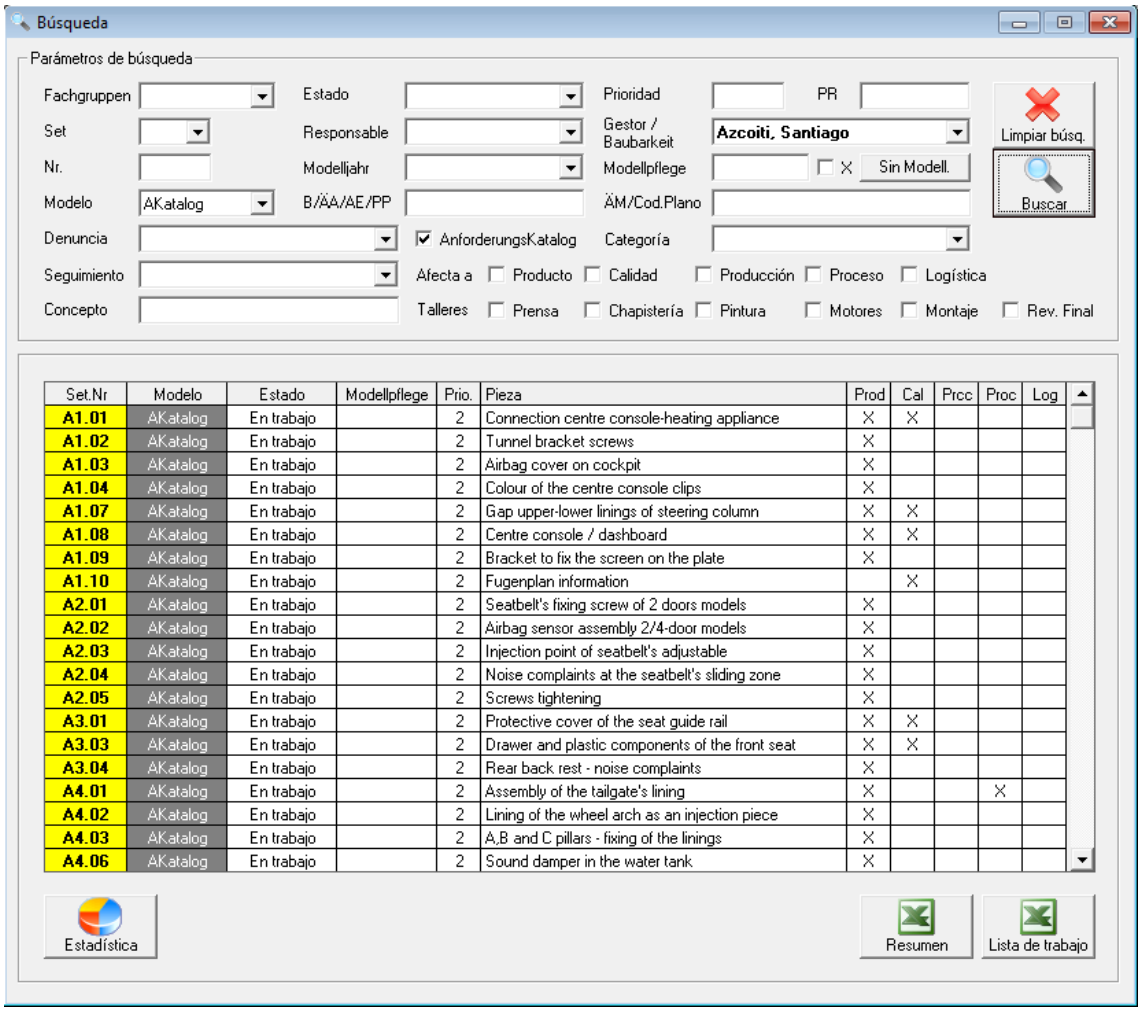
Lastly, it must be established the **status of the problem through the colours of a traffic light**, red, yellow and green. If the problem is red coloured it means that it is blocked, they may exist problems when modifying it trying to achieve a solution. If the colour is yellow it implies that they are working on it, looking for measures to modify the product or the process in order to solve the problem, with the lack of knowledge of its approval. Finally, if the colour is green it involves that the change studied to finish with the concern is in phase of acceptance.

6.3.3 "AKatalog"

Until now there were 3 different models introduced in GESPRO inside the field of "Modelo": the A05, A05GP and A07. To collect all the requirements of the developed catalogue of the current project a **new virtual model called "AKatalog"** was enabled. However, the goal of this new model introduced is completely different from the purpose of the rest of them. While the models A05, A05GP and A07 were introduced to save all the problems emerged in the correspondent model and to keep the monitoring of every single one (controlling the status with the traffic light colours and achieving several product modifications), the "AKatalog" is orientated to a completely different concept. The idea is to **save all the generic requirements** studied and developed over the past months in the recently experienced internship. Thus, from now on if a new car model appears, all points from "AKatalog" will be copied into the field of the new model to study one by one and put them one traffic light colour as it was explained in the previous point.

All the points of "AKatalog" are ordered by the Sets previously explained. Below the title "Pieza" (piece) a title is shown for every single point to clarify the piece/zone that is handled in the correspondent point. They shouldn't be yellow coloured but the program forces by default to apply a traffic light colour because, after all, the purpose of

GESPRO is to **colour each of the problems that emerge** and are introduced into the program depending on the status of every one of the mentioned problems. The following picture shows the first points that appear selecting "AKatalog" in the field of "Modelo".



Set.Nr	Modelo	Estado	Modellpflege	Prio.	Pieza	Prod	Cal	Prcc	Proc	Log
A1.01	AKatalog	En trabajo		2	Connection centre console-heating appliance	X	X			
A1.02	AKatalog	En trabajo		2	Tunnel bracket screws	X				
A1.03	AKatalog	En trabajo		2	Airbag cover on cockpit	X				
A1.04	AKatalog	En trabajo		2	Colour of the centre console clips	X				
A1.07	AKatalog	En trabajo		2	Gap upper-lower linings of steering column	X	X			
A1.08	AKatalog	En trabajo		2	Centre console / dashboard	X	X			
A1.09	AKatalog	En trabajo		2	Bracket to fix the screen on the plate	X				
A1.10	AKatalog	En trabajo		2	Fugenplan information		X			
A2.01	AKatalog	En trabajo		2	Seatbelt's fixing screw of 2 doors models	X				
A2.02	AKatalog	En trabajo		2	Airbag sensor assembly 2/4-door models	X				
A2.03	AKatalog	En trabajo		2	Injection point of seatbelt's adjustable	X				
A2.04	AKatalog	En trabajo		2	Noise complaints at the seatbelt's sliding zone	X				
A2.05	AKatalog	En trabajo		2	Screws tightening	X				
A3.01	AKatalog	En trabajo		2	Protective cover of the seat guide rail	X	X			
A3.03	AKatalog	En trabajo		2	Drawer and plastic components of the front seat	X	X			
A3.04	AKatalog	En trabajo		2	Rear back rest - noise complaints	X				
A4.01	AKatalog	En trabajo		2	Assembly of the tailgate's lining	X			X	
A4.02	AKatalog	En trabajo		2	Lining of the wheel arch as an injection piece	X				
A4.03	AKatalog	En trabajo		2	A,B and C pillars - fixing of the linings	X				
A4.06	AKatalog	En trabajo		2	Sound damper in the water tank	X				

Figure 65: "AKatalog". Source: **GESPRO, Volkswagen Navarra.**

As it can be seen in the previous picture, the only boxes that were selected were "Modelo" and "Gestor" (manager), so this involves that all the introduced requirements of the "AKatalog" model appeared, ordered by Sets. However, many other search **parameters** exist **to filter the points and make a more concrete research**. For example, it is possible to filter the "AKatalog" points by "Fachgruppen" (professional group), so it would be obtained the following points of "Ausstattung", "Karosserie", "Fahrwerk", "Elektrik" or "Aggregate". If the person that is employing GESPRO needs

a more precise search, it is possible to filter the points by a concrete Set (A1, A2…) to avoid having to search manually the points of one Set inside all the model points. It is also possible to select the "Estado" (status") field to filter the points by their status, that is, it is possible to obtain all the points that are, for example, yellow coloured, involving that those points are being studied and remain pending of the modification validation. All points introduced in the current virtual model were set as priority 2, as all are equally important and this numbering is thought mostly for the other models that are daily studied and uploaded, so it is important to know if one point is priority 1 because it is urgent to find out a solution. For the points of the catalogue, this is obviously not the case. Finally, there is another possibility of filtering the search that is the blank field "Concepto" (concept) where the employee can write whatever he wants, the name of a concrete piece for example, to find all the points related with it.

If one point is clicked, another window is opened with all the information about the correspondent point. Furthermore, GESPRO program **allows extracting an Excel sheet with a summary** of all the introduced points with a bit of information about each of them, as well as a working list with the information about the different status that currently have the points and, finally, individual sheets about every single point with all the information about the wished point. Following the current paragraph some examples are shown to clarify the structure of the requirements.

-Example 1:

For example, if the **point K1.01** (first point of the K1 Set), that **involves presses and sheets**, is clicked, the following window would be opened:

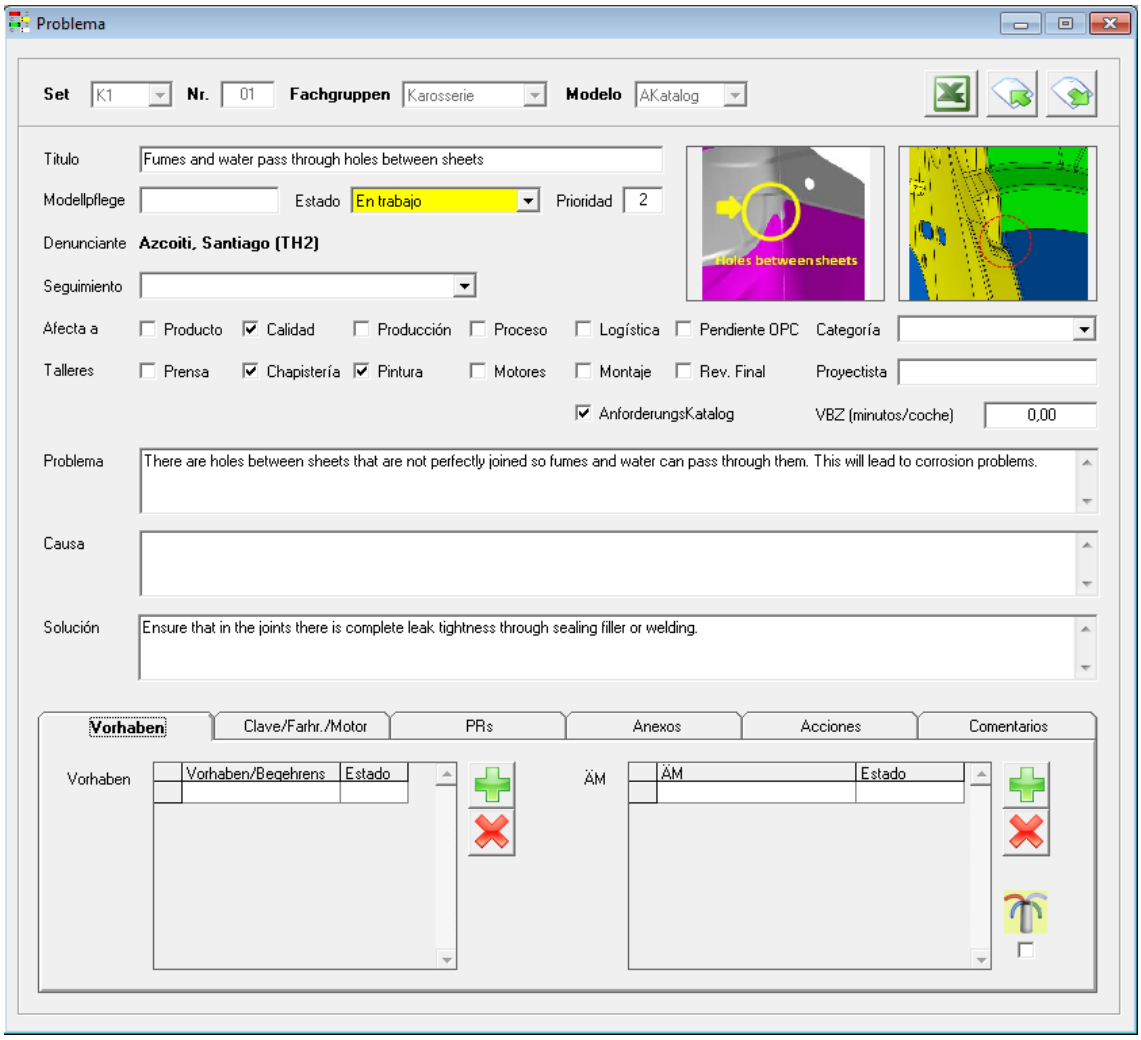


Figure 66: K1.01. Source: **GESPRO, Volkswagen Navarra.**

The current point described corresponds to the **first example of Concept Analysis explained** before, as this point emerged from that source. As it can be seen, in the top of the window the first information shown is related with the Set (K1), the point number (01) inside the correspondent Set, the professional group ("Karosserie", that is, car body) and the model ("AKatalog"). Down below the title that appeared before in the main window appears also here. The status and priority number are shown in addition. Afterwards, **the name of the complainant appears**, that is the same for all the points introduced in "AKatalog". At the top right of the window there is a space for pictures to clarify the requirement that is usually used. The boxes of the different departments and workshops affected and involved are filled down below. The main department involved in this point is "Calidad" (Quality) because the corrosion is the main problem of the

current point that is present and must be solved with accuracy by the mentioned department. Concerning the workshops involved, in this case the ones that are affected are “Chapistería” (Body shop) and “Pintura” (Paint shop) as the possible solutions involved the appliance of sealing filler (carried out by Paint shop) and/or by welding (carried out by Body shop). To conclude the description of the requirement, there are two writing spaces that must be fulfilled in all points, concerning the description of the current problem and, later on, the possible proposed solution. Finally, there is an important tab called **“Anexos” (annexes), where all the related pictures** (showed at the top right of the window) **and documents are saved**, so any engineer could have a look at it to have more information about the requirement.

There are many other fields that are only employed by engineers that work daily with problems in the other models but have not been employed neither fulfilled in the current project.

-Example 2:

The second example emerged in this case from the visit to the door’s line (implemented in the Engine shop) with a specialist of the area. The point to be improved was the following: the **doors have** some **holes** in their upper zone **where the KTL** (cataphoresis treatment) **is introduced to cover the door’s interior tubular to avoid future problems of corrosion** in that zone. The following picture shows the mentioned holes and the stickers.

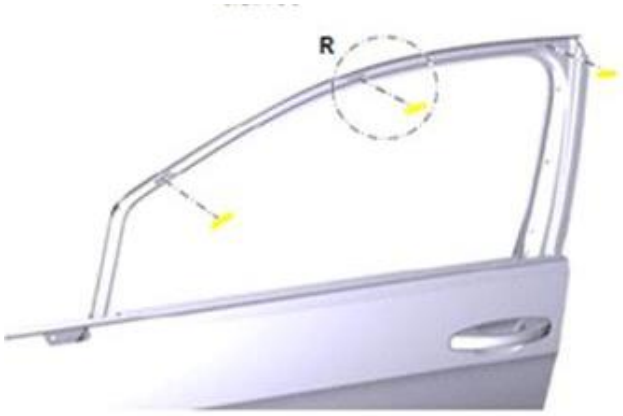


Figure 67: Stickers (yellow) to cover door's KTL holes.
Source: **Volkswagen Navarra.**

However, these holes must be afterwards covered with some stickers placed by the operators. The specialist thought that these **stickers should be avoided** in order **to reduce** two things: **costs and cycle time**. As these holes must be covered, what should be the solution to eliminate the stickers and keep covering the holes? The solution was simpler than expected. The idea was to **copy the concept carried out in** another model of the brand, **the Volkswagen Golf**. This model doesn't have any sticker to cover those holes and has another different thing from the Polo. In both of them, there is a piece called **side window seal** that is assembled in the doors line and covers that zone to protect door, but the one employed in the Golf **has some nerves that get inside the KTL holes** so the nerves cover them and there's no need of using stickers.

After knowing the requirement to be implemented from now on, next step was to introduce that point in GESPRO's "AKatalog" model. In this case, it was catalogued into K6 FG category; in particular it was the **point K6.13**. As it can be seen in the picture down below, the requirement affects to the product, as it has to be changed because the side window seal has to be different from the one employed before, and it also affects to the process because the step of covering the holes with the stickers will disappear as well as the assembly of the side window seal will be slightly modified cause the operator would have to ensure the correct introduction of its nerves inside the KTL holes. Regarding the workshops affected, these would be Paint shop (due to the stickers that were put in that workshop after the KTL treatment) and Engine shop (cause the doors line takes place in that workshop). Two pictures were introduced to clarify the idea: the one on the left side corresponds to the picture showed previously of the KTL holes and the yellow stickers to cover them that were employed before; the picture at the right side corresponds to a dimensional drawing of the side window seal employed in the Golf that should be now used for the Polo. The following picture shows the window correspondent to the described requirement in GESPRO (K6.13).

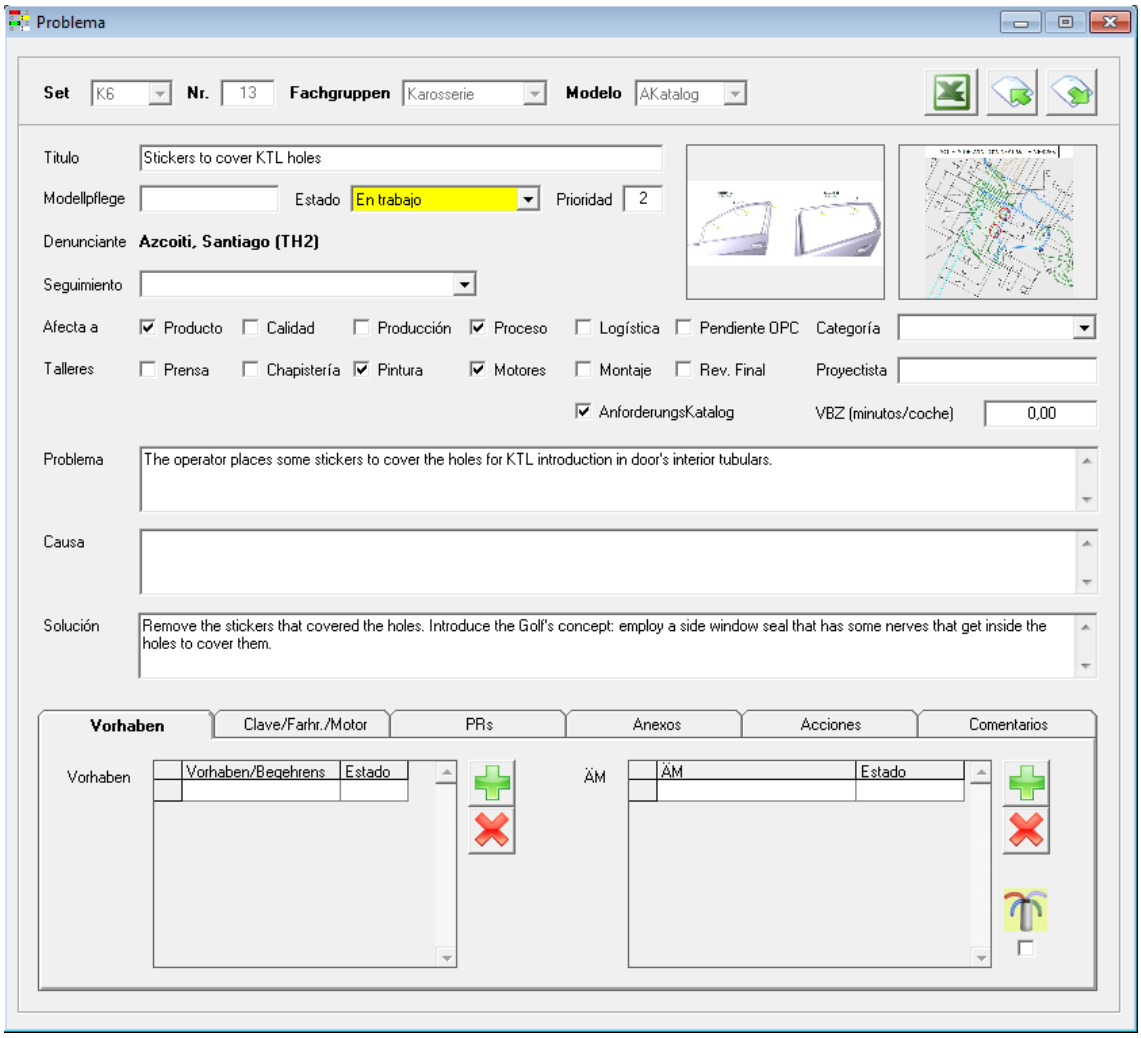


Figure 68: K6.13. Source: **GESPRO, Volkswagen Navarra.**

-Example 3:

The third example explained talks about a **requirement already described in the Concept Analysis point as the fourth example**. This requirement talked about the **necessity of a grid zone at the centre of the water box** to ensure the evacuation of water, avoiding the entry of water into the air vents of the heater. The picture right after the current paragraph shows the complete description of the requirement already introduced in GESPRO as the **point K1.04**. As it can be seen, the point affects to Quality department as that water accumulation wouldn't pass the quality standards and to Product as the water box must be modified in order to evacuate efficiently all the

water. Concerning the workshops affected, the main one affected is Body shop as it is the workshop entrusted of changing the geometry of the water box.

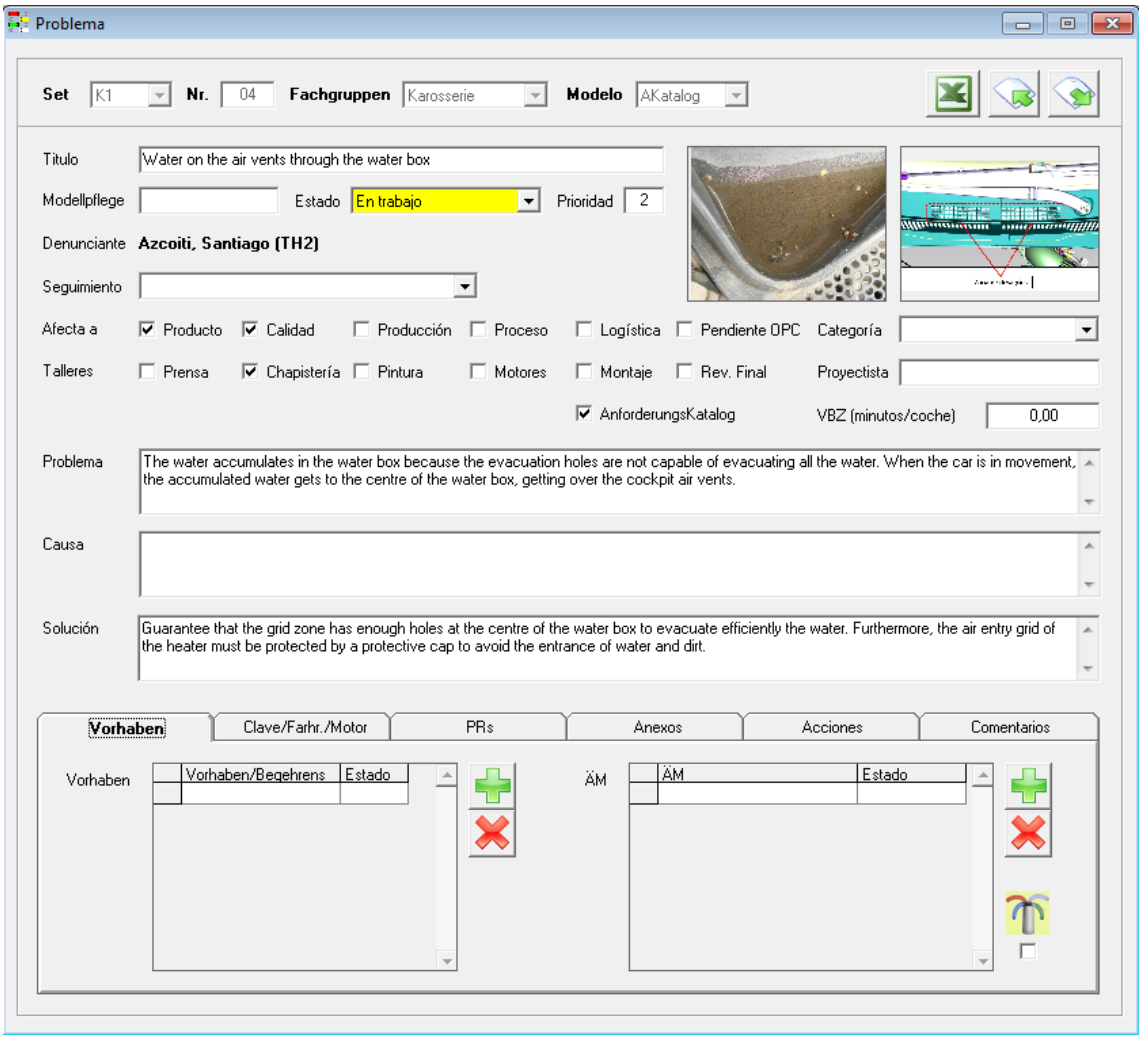


Figure 69: K1.04. Source: **GESPRO, Volkswagen Navarra.**

-Example 4:

Another example of the requirements catalogue is related with the **first example of** the fifth consulted source, **Contacts round,** where the idea is to improve the ergonomics of the workers and reduce the fabrication time by **changing the assembly concept of the lower fixing of the door's lining panel**, moving from the A05GP's concept with screw, nut and forming zone to the Golf's concept with a clamp and removing screw and nut, avoiding the sheet's forming zone. As it can be seen in the picture down below, the described point corresponds to the **A6.03 point of the requirements catalogue**. It has

annexed the two pictures showed before and it describes the problem and the solution. As the forming zone is removed, the Product department is affected. Moreover, this affects to Production department and Body shop as the sheet must be modified. Finally, the Process is affected due to the change of the assembly process, so the Engine shop (where door's line takes place) is also affected.

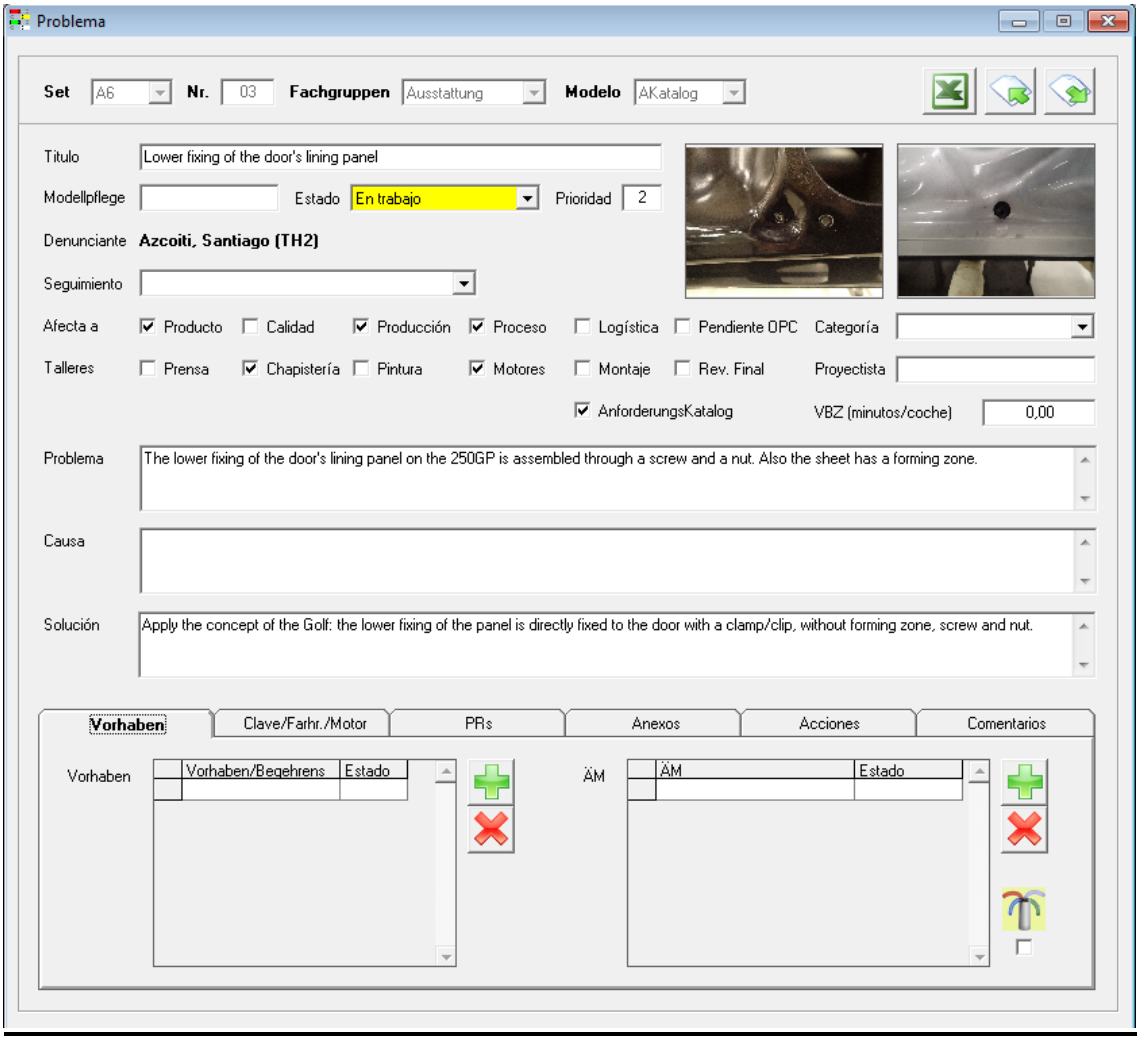


Figure 70: A6.03. Source: **GESPRO, Volkswagen Navarra.**

7 EVALUATION OF INFORMATICS TOOL

The seventh point is thought to present the methodology that is currently being used in order to understand its functioning and to see the advantages and drawbacks it has. Some possible improvements will be proposed to possibly improve the working method and the usability. Those improvements are simple ideas to avoid wastes of time when searching for a problem in GESPRO.

7.1 Analysis of actual methodology

Beginning by analysing the methodology currently used, it is important to know completely the way the diverse documented problems are structured into GESPRO program and how the people of Volkswagen work to make the monitoring of each of them to be able to solve them and avoid it in the future.

To start, first thing to happen is seeing the problems. The **people entrusted of the assembly** of the different pieces and sets of the car are those who **have more chances to find a problem** or a point to be improved, since they work every single day with them and see first-hand not ergonomic methods or others that are tough to be assembled. Furthermore, the **people in charge of every assembly line who must check constantly every step carried out** in the corresponding area have to study the current methods and see what could be refined and where it is possible to improve to ease the work of the employees and to avoid safety risks and weariness. Regarding the prototypes, either the workers entrusted of their assembly or those that must supervise should be able to detect the problems or points to be changed. **Whoever sees a problem, he must denounce it immediately** to be able to solve it as soon as possible, being able to propose a possible solution that will have to be carefully analysed and studied with detail. Depending on the affected area, it will be one or other department that should take charge of the tracking of the problem until it finds out the best solution. As it was already explained before, **the FG to which the denounced problem should belong will be in charge if delegating it to the correspondent Set**, so this one will have to study it thoroughly to find a solution that will be discussed further on and deeply studied. However, in some cases it is not so easy to know to which FG

corresponds a problem as it may involve more than one FG due to the joint of problems into one single one. This involves that the distribution of FGs could be modified, but the possible modifications are mentioned afterwards in next point, regarding possible improvements.

When the solution that is believed to be the best one has been found, this one is **sent to the counterpart working group of the headquarters in Wolfsburg** so that they study it with detail and decide if it is feasible or no to introduce it, approving the product modification if finally the engineers accept it after the different opportune designs they should have done to verify that the modification does not give any problem and it has passed successfully the different tests and virtual verifications. **Stated modification will have to be**, after being produced and assembled in a series model or prototype, finally **tested to see if it fulfils 100%** with the established conditions so that its introduction could now be definitely approved in series cars, so all vehicles that take place at the production lines have said modification. If the proposal that was sent to the headquarters is not finally accepted, it is possible that the German engineers send back a different proposal that should be previously proved. If not, the Set of VW Navarra will keep on working to finally find out a feasible solution.

In GESPRO it is crucial to update constantly all the information about every single point concerning last modifications recently introduced. In the news section, the latest changes will appear so the employees are informed, **with ÄKOs (product modification)** approvals, status changes and so on. The problem is that as days pass by, some news must be removed in order to be substituted by new ones. It would be necessary to have a time tracking of the changes without losing information. Furthermore, the **employee can extract Excel sheets about all the information** of any individual point or the entire list, but the possibilities are reduced and it could be optimized, as well as the limited statistics that can be shown concerning the points from one model, involving that they end being not used by the engineers. In the next section, the possible changes proposed are explained.

7.2 Possible improvements

Until now the FG entrusted of monitoring and solving the different problems were 5 ("Ausstattung", "Karosserie", "Elektrik", "Fahrwerk", and "Aggregate"), each of them divided into Sets depending on the zone/pieces that were affected. However, the **working group of "Pilothalle" is starting to work with new FGs**, which are the following:

- "Frontend": front part of the car (bumper, bonnet, etc.).
- "Heckend": rear part (rear bumper, boot, etc.).
- "Türen": doors.
- "Interior/Exterior": linings, cockpit, etc.
- "Motor Fahrwerk": engines, suspensions, steering, brakes, exhaust system, etc.
- "Elektrik": wirings, electronic components, control modules, sensors, etc.
- "Korrosion": corrosion.

These new FGs could be a **good idea to be implemented for the storage of problems in GESPRO**, as it would be clearer to what FG each of the problems would correspond to, avoiding the existence of a big number of Sets that need some groups to be specialized in a very concrete zone of the car. It would be more efficient to have a FG, for example, entrusted of all the front part of the car, with specialists that know about sheets, linings or painting to reach the best possible solutions to solve any kind of problem of the mentioned zone of the car, instead of having a group only entrusted of the sheets and other of the painting that could involve future problems because, for example, a zone of the sheet makes difficult the appliance of sealing filler.

Furthermore, the current methodology only allows introducing a requirement/point in one concrete Set, but **an improvement would be that GESPRO allowed introducing one requirement in more than one Set.** For example, if there is a requirement that demands that all the pipes' connections have different colours that match with their corresponding pairings to avoid mistakes from the workers, this requirement should be guaranteed in all pipes' connections, and so it would involve the pipes of the air conditioned system (A5 Set), fuel pipes (F5 Set), pipes from the engine compartment (M3 Set) and so on.

GESPRO program also allows obtaining Excel sheets about an individual point or the entire list of the introduced points of one model. However, to speed up the work of the people entrusted of one Set, it would be a **good idea to have the possibility of extracting an Excel sheet with all the points from one entire Set or from one entire FG**, so the employees would not have to wait so long for the Excel to be extracted and their search for the points they manage inside the entire list of points would be avoided.

When someone wants to filter the list to optimize the search of concrete points, there are some fields that allow focusing on a determined issue. Thus, the employee can search in GESPRO by FG, Set, model, current status, manager, etc. Nevertheless, if the employee wants to filter the points per dates, it is not possible. Only in the daily news the last status changes can be seen with the modification date correspondent, but every few days that news are removed and substituted by new ones, having **lack of knowledge in a point explanation of when it was introduced or when it changed its status for the last time**. For that reason, an improvement to be implemented could be the inclusion of the dates tracking from every point, as for example the introduction date in GESPRO, the date of every modification one point has suffered and the date of the last change of one point, having the **possibility to filter the entire points list by date to be aware of the implemented modifications in stated dates** or being able to see if a point has been a lot of time in work status or cancelled to know what points need to give more attention in order to solve them.

Finally, the GESPRO program allows the user to extract some statistics related with the current status of all the points from one model. However, this tool is not commonly used by the employees. Maybe one modification should be to **allow the statistics to show the percentage of introduced problems from every FG and Set**, so it would show graphically the amount of problems of each group to see the ones that are the most problematic of all and possibly increase the efforts in those areas with more people working on the solutions.

8 CONCLUSIONS

In such a **globalized and overcrowded market** as the one of the car industry, it is essential to keep **updating models and developing new technologies** to arrive to the customers, taking into account that their wishes and needs constantly vary, and to reach the best possible market position with new innovative solutions, needing to **reorient the features and quality of the car** as well as adapting to the changes and progresses experienced worldwide with new strategic programs trying to respect the environment as much as possible, something that is really considered by the clients nowadays. Their strategies must be strong and fast, with a clear idea of the product they want to launch to the market and with an **accurate and efficient process** to achieve it.

Nevertheless, without a precise and determined method to reach the objectives it would be impossible to be at the top. That's why it is crucial to have a **deeply studied and developed process to design, produce and launch a new product**, in this case a new car model. Thus, the Volkswagen Group has been employing the PEP method as the process to develop a new vehicle, with a lot of steps that must be fulfilled carefully. **To ease the engineers and designers work, the generic requirements catalogue has been developed**, with a lot of technical requisites that should be studied if they are feasible or not to be introduced, as the same requirement could be feasible for one model but not for another. These requirements have been **extracted from several sources** already described, with special attention to problems in series vehicles and prototypes that had to be studied and solved, as well as guaranteeing the continuity of successful methods, proposing new ones to reduce costs and cycles times, improving workers ergonomics, standardize product variants, and so on.

Before reaching the perfect assembly of the car, one of the most important events of every new product emergence process is the assembly of prototypes, the first real representations of what will be the final car. Thus, **prototypes are the perfect tool to make different tests**, like assembling and disassembling them many times to test all the produced pieces and see what kind of problems emerge there and how to solve them in order to avoid them in the future final car, so in the assembly line they would be completely avoided.

The **own experience and work**, combined with the great help and **support received from multiple specialists** with wide knowledge and expertise about the different steps carried out in the production process and the small details that only them are capable of observing and identifying, were the **main keys for the development of the requirements catalogue**, having the chance to see first-hand the problematic points that had to be resolved, as well as those that had been already solved and it should be guaranteed that they didn't reappear; also the aspects to be improved, etc.

Ultimately, the catalogue's mission is that it must serve **as model to ensure the assembly reliability of every model** from Volkswagen Group, especially thought for the models of Volkswagen, as it is from where it has emerged and to the brand it is better adapted, even though it could perfectly adjust to the models of the rest of the brands with some minor changes. It is expected to serve to **guarantee the deadline achievement of the PEP method**, being an important reference to be fulfilled into the project premises.

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10 ANNEXES

Annex A: Example of an Excel sheet extracted from requirement A2.02 of "AKatalog"

Volkswagen Navarra, S.A.

DISKUSSIONSPUNKT

Projekt	**AKatalog**		
Titel	**Airbag sensor assembly 2/4-door models**		
Ersteller Abt Ersteller Treiber Abt. Treiber Verantw. Abt. Verantwortlicher Löser Abt. Problemlöser	Azcoiti, Santiago	Erstellt am 15/3/2016 SET . Nummer / Projekt A2.02 / AKatalog	
Fehlerherkunft	☑ Produkt ☐ Qualität ☑ Montage ☑ Prozess ☐ Logistik		
Problembeschreibun	Different assembly of 2 and 4 doors models leads to unfavorable synchronization (uneconomical) and part variety.		
Fotos			
Teilenummer	Teile	Status	
Fahrzeugdaten	Projekt Bez. AKatalog Model Status Fzg. Nr.	Ort Fehlerfin Fgst.-Nr.	
Motor	Hubraum KW Kraftstoff	Motor Nr. Getriebe Lenker	
Letzte Analyse			
Letzte Maßnahme	Standardize the assembly process of the airbag sensor in both cases, 2 and 4 doors models.		